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MEMOIRS OF THE GEOLOGICAL SURVEY

ENGLAND AND WALES.

THE GEOLOGY OF THE SOUTH WALES COAL-FIELD.

PART VII.

THE COUNTRY AROUND

AMMANFORD.

BEING AN ACCOUNT OF THE REGION COMPRISED IN
SHEET 230 OF THE MAP.

BY

AUBREY STRAHAN, M.A., Sc.D., F.R.S., F.G.S.,
T. C. CANTRILL, B.Sc., F.G.S., E. E. L. DIXON, B.Sc., F.G.S.,
AND
H. H. THOMAS, M.A., B.Sc., F.G.S.

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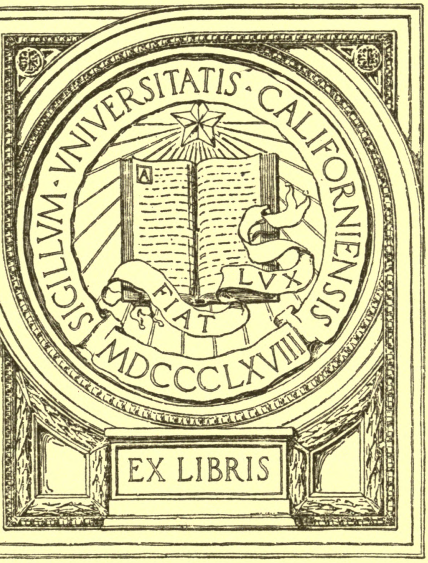

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PREFACE.

The country around Ammanford, which is described in the seventh part of the Memoir on the Geology of the South Wales Coalfield, is illustrated in Sheet 230 of the New Series one-inch map.

The original survey was made by Sir H. T. De la Beche, [Sir] W. E. Logan, [Prof.] John Phillips and [Sir] A. C. Ramsay on the Old Series one-inch maps 41 and 37, and was published in 1845. Some additions were made to the mapping of the Silurian areas by W. T. Aveline in 1857.

The resurvey was made on the six-inch scale under the superintendence of Dr. Strahan and the new edition of the one-inch map, based on this resurvey, was published in 1907. The areas surveyed by the members of the staff engaged are as follows:

Dr. A. Strahan—Carmarthen 54 S.E.; 55 S.W. Glamorgan 3 (Brecknock 43, Carmarthen 50) N.W. and S.W.; 7; 8; 9 N.W. and S.W.

Mr. T. C. Cantrill—Carmarthen 41 N.E. and S.E.; 42; 43 N.W. and S.W. (37 Brecknock); 47 N.E. and S.E.; 48; 49 (2 Glamorgan).

Mr. E. E. L. Dixon—Carmarthen 54 N.E.; 55 N.W.

Mr. H. H. Thomas—Carmarthen 40 N.E. and S.E.; 41 N.W. and S.W.

In the present volume each surveyor supplies the description of the ground surveyed by himself.

The changes made in the map as the result of the resurvey are numerous and important. Cambrian rocks have been recognised, and the Arenig, Llandilo and Bala series of the Ordovician system have been distinguished. In the Silurian rocks various lithological subdivisions have been made, which do not wholly agree with the grouping formerly adopted. The 'Upper Llandovery' strata, for example, appear to belong to the Wenlock, and the upper part of the Ludlow group is now distinguished by colour into Grammysia-bed, Trichrûg-beds and Tilestones. The overstep of the Silurian rocks by the Old Red Sandstone is well brought out by the mapping of these subdivisions.

The detection of radiolarian cherts has enabled a closer comparison to be made between the Carboniferous rocks of South Wales and Devonshire than was formerly possible.

The part of the Coalfield illustrated has not been fully exploited. In the central part of the basin the great thickness of overlying measures has discouraged attempts to reach the

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lower seams. Those seams where they come to the surface in the North Crop are all anthracitic. In the South Crop, on the other hand, they are all bituminous, and there is little doubt that in the intervening ground they pass through the intermediate stage of steam-coal. The thickness of the measures, upon a knowledge of which calculations as to the depth to be sunk in any part of the Coalfield to the lower seams depend, has received careful consideration.

The Pennant Series contains some valuable coal-seams in its upper part, so that the distinction between it and the Upper Coal Series is less definite than in the eastern half of the Coalfield. The base of the series, moreover, has proved difficult to follow owing to the development below it of the Llynfi rock, which closely resembles Pennant sandstone. The coal-seam, which forms a convenient, though arbitrary base to the series through much of the Coalfield does not exist here in workable form.

The thickness of strata cropping out within the limits of Sheet 230 amounts to little less than five miles. The structure by which so huge a mass of sedimentary material has been exposed at the surface, is simple in its broad outlines. Towards the north the Carboniferous, Old Red Sandstone, Silurian and Ordovician rocks are all tilted up along a belt of disturbances which runs through Llandilo and Carmarthen. The disturbances take the form of overfolding and overthrusting, and are proved to have been repeated along the same general line of country at several different geological periods.

Glacial phenomena are finely developed in this part of South Wales. For the most part the ice moved southwards, crossing all except the biggest hills. Even the vale of Towy failed to control it wholly, for while the lower layers of the ice passed down that great hollow westwards, the upper layers escaped from it southwards over the cols in the Old Red and Silurian escarpments. In several other cases differential movement between the upper and lower layers of the ice-sheet has been demonstrated. The general southward trend is difficult to explain except on the supposition that there was a great development of ice in the region lying further north.

In chapter xiv will be found an account of the economic products of the district, exclusive of coal.

In an appendix is given a list of all the fossils from the lower Palæozoic rocks which have been collected by officers of the Survey, and which are deposited for reference in the Survey Collection. In describing these rocks in the earlier chapters the authors have identified as far as possible the localities from which previous workers have collected; all the specimens recorded in the fossil-lists are preserved in the Survey Collection unless otherwise stated.

The map is issued in two editions. On the edition for Solid Geology the glacial deposits are omitted, while on the edition for Superficial or Drift Geology, those deposits are shewn by colour, as well as the Solid Geology where it is not concealed by them.

Great assistance has been rendered by mining engineers and mine-managers within the limits of the Coalfield. Our thanks are due especially to Mr. John Roberts, Mr. Morgan W. Davies, Mr. Capel A. Branfill, Mr. E. H. Hedley, Messrs. Griffith and Pollard, Messrs. Thomas Williams and Sons, Mr. E. R. Fisher, Mr. Thomas Lloyd, Mr. John Hay, Mr. John Thomas of Brynamman, and Mr. Thomas Jones of Glanamman. Of the information furnished by many others acknowledgment is made in the text.

J. J. H. TEALL,
Director.

Geological Survey Office,
28, *Jermyn Street, London.*
8th April, 1907.

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GEOLOGY

OF THE COUNTRY AROUND

AMMANFORD.

CHAPTER I.

INTRODUCTION.

By A. Strahan.

Physical Features.

Sheet 230 includes a small part of the valley of the Towy, the western end of the Black Mountains, and that part of the coalfield which lies between the Dulais Valley on the east and the Lliedi Valley on the west. The greatest elevations are reached on the Millstone Grit plateau of the Black Mountain, which ranges up to 2,076 feet in Esgair-hîr, 2,026 feet in Gareg-lwyd, and 1579 feet in Tair Carn. The Old Red Sandstone, though further east it forms the dominant escarpment, here becomes subsidiary to the Millstone Grit and seldom exceeds 900 feet in height. In the coalfield, the Pennant Grit presents its usual characteristic plateau-scenery in the mountain-land between the Dulais and the Loughor, but has lost much of the boldness of the scarps and tablelands which characterises it in the ground to the east. Mynydd March Hywel, 1,371 feet, and Penlle'r-castell, 1226 feet, are the highest points to the east of the Loughor; west of that river the Pennant nowhere quite reaches 1,000 feet.

In all these formations the bolder scenery and the broader tracts of mountain-land lie to the east of the Loughor, but the ridge of nearly vertical Old Red Sandstone, Silurian and Ordovician rocks which overlooks the Towy Valley from the south, though rising to no great height, is a conspicuous feature in the landscape.

The region is drained by the Towy, Gwendraeth, Loughor, Tawe and Neath, the Dulais being a tributary of the last-named river. (*See* Map forming Fig. 12, p. 189.) The Towy flows from east to west, along the strike of the rocks and along a belt of disturbances of great intensity. It receives as a tributary the Cennen, which rises on the northern flanks of the Black Mountains, runs westwards for four or five miles along the strike of the beds, and then turns abruptly northwards across them.

The head-waters only of the two Gwendraeths are included in the map. They flow westwards along the outcrop of the Lower Coal Series and of the Old Red Sandstone respectively.

The Loughor and its feeder the Marlais rise in the same region as the Cennen, but turn southwards at the same point where the Cennen turns northwards, the two valleys being actually continuous save for a low bank of gravel. The Loughor receives on its left bank the Amman, which follows the hollow so constantly associated with the outcrop of the Lower Coal Series, and the Dulais ; on its right bank, the Gwili and the Morlais.

The Tawe occupies a deep narrow and remarkably straight valley running nearly south-west. On its right bank it collects the Giedd, Gwys, Twrch and Llynfell, which descend the long southern slopes of the Black Mountains, and lower down receives the water brought from the Pennant tract by the Upper and Lower Clydach.

The rivers thus divide themselves into two classes, namely, those which follow the strike of the rocks, as, for example, the Towy with a part of its tributary the Cennen, and the Gwendraeths, and those which flow across the outcrops, such as the Loughor and Tawe. The water-parting between these two classes runs through the Black Mountain, and thence by Cross Hands, passing between the Marlais and the Cennen.

Population and Agriculture.

The industrial part of the population is concentrated in the valleys, in many of which the mine-ground was worked and the ore smelted in former years. This industry is defunct and the working of anthracite and steam-coal has taken its place. Tin-plate and other works provide much additional labour. Apart from the valleys the population is scattered in farms, but large areas in the Black Mountains and some in the Pennant hills are uninhabited. This mountain-land is used only for pasturing sheep, and most of the lower ground is devoted either to the same purpose or to dairy-farming and growing such crops as may be necessary for home-consumption. Arable land is confined chiefly to the tracts occupied by gravels or Pennant rock, the boulder-clay in its more clayey form being too heavy and wet. Lime was formerly burnt in innumerable places for agricultural purposes, but has now almost entirely given place to basic slag and various phosphates as a dressing.

The water-supply is derived mainly from springs, or from the impounding of surface-water. Part of the supply for Swansea is derived from reservoirs in the Lliw Valley, and of that for Llanelly from reservoirs in the Lliedi,

Table of Strata and Classification.

The formations enumerated in the following table are distinguished upon Sheet 230. Not only the number but the total thickness of formations is exceptional. Taking the average thickness of each formation and adding them all together we get a total of 8,430 yards or very nearly five miles. It must not be assumed, however, that all the formations would be present, or would reach even their average thickness, in any one vertical column.

Alluvium	Recent and Post-Glacial.	Superficial.
Peat		
River Gravels (Terraces and Deltas)		
Boulder Clay	Glacial.	
Sand and Gravel		
Upper Coal Series with the Wernffraith or Swansea Four-feet Vein at its base	Coal Measures.	Carboniferous
Pennant Series with the Ynysarwed, Garn Swllt or Brondini Vein at its base		
Lower Coal Series with Cockshot and other sandstones		
Farewell Rock, impersistent	Mill-stone Grit.	
Shales with sandstones		
Basal Grit with Plastic Clay Beds		
Upper Limestone Shales (Rottenstone Beds)	Carboniferous Limestone Series.	
Limestone with sandstone		
Lower Limestone Shales		
Grey Grits, impersistent		Old Red Sandstone.
Brownstones with Pebbly Beds at their top		
Senni Beds		
Red Marls with Green Beds at their base		
Tilestones	Passage Beds, Ludlow and Wenlock Series.	Silurian.
Trichrûg Beds		
Grammysia Bed		
Mudstones with Lletty Grit		
Slade and Redhill Beds	Bala Series.	Ordovician.
Bala Limestone		
Dicranograptus Shales with Limestone		
Flags with limestones	Llandilo Series.	
Ffairfâch Grit		
Didymograptus bifidus Beds	Arenig Series.	
Ogygia marginata Beds		
Peltura punctata Beds	Tremadoc Series.	Cambrian.

The seam known as the Ynysarwed at Ystradgynlais corresponds to that known as No. 2 Rhondda further east and is therefore taken as the base of the Pennant Series. West of Ystradgynlais, however, the Ynysarwed Seam had never been continuously traced and the name drops out. But it was generally believed that a coal worked at Garn Swllt in the Loughor Valley corresponded to it, and this correlation proved to be in accordance with the mapping and with the fact that the Garn Swllt Vein has the same sort of rock and conglomerate above it as that overlying the Ynysarwed or No. 2 Rhondda Seam. The difficulty, however, of tracing this horizon increases west of the Loughor, where the vein has not proved worth working. The evidence for its identification around Llannon, which is given in some detail in Chapter IX, appears to link it up with the Gyscwm Vein of Pembrey (Sheet 246).

The Lower Coal Series, in which are included all the anthracitic seams, passes upwards into the Pennant Series and downwards into the Millstone Grit. At its top the sandstones to which the name of Llynfi Rock was applied in the central part of the coalfield, and of Tormynydd Rock in the South Crop, closely resemble Pennant; at its base there are sandstones indistinguishable from the Farewell Rock. The top of the Farewell Rock is selected as a convenient base, but the rock itself is impersistent, and the division of Coal Measures from Millstone Grit is quite arbitrary.

The basal Millstone Grit loses its pebbly character in the western part of the area under description, and at the same time tends to pass down into the Carboniferous Limestone. No such passage exists in the eastern part of the coalfield* nor in the Neath Valley,† where quartz-conglomerate rests directly upon limestone. Even in the Tawe Valley, where the Rottenstone Beds come in between the two, there is no transition from one to the other.‡ Here however, a set of sandstones and cherts (the Plastic Clay Beds) appears next below the grit, and lessens the gap in the lithological passage. It is to be noted also that in the South Crop in Gower, where it is represented by shales in which sandstones are quite subordinate, the Millstone Grit graduates lithologically down into the Carboniferous Limestone through a series of cherts.§ The character of the quartz-conglomerate suggests that it was a delta-formation and the facts referred to point to its having been spread in South Wales from the north-east towards the south-west.

The Grey Grits, which are classed with the Old Red Sandstone, but might lithologically be regarded as the basement-bed of the Carboniferous, overstep a part of the Brownstones. Their base, however, is in places ill-defined, and certainly there is no unconformity in any part of the Old Red Sandstone comparable to that which is stated to exist between the Upper and Lower Old Red Sandstone of other regions.

The sub-divisions of the Silurian rocks enumerated in the Table appear only in the eastern part of the map; westward they both thin away and are also overstepped successively by the basal beds of the Old Red Sandstone, which then rest with an obvious unconformity on various members of the Ordovician System.

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* 'The Country around Abergavenny,' 1900, chap. v, *Mem. Geol. Surv.*

† A. Strahan in 'The Country around Merthyr Tydfil,' 1904, pp. 29, 30, *Mem. Geol. Surv.*

‡ *Ibid.*, p. 19.

§ 'Summary of Progress' for 1900, pp. 87–90, *Mem. Geol. Surv.* *Also* 'The Country around Swansea,' 1907, p. 22, etc., *Mem. Geol. Surv.*

The west-south-west disturbances, which are ushered in by the Vale of Neath Disturbance (Sheet 231), increase in frequency and intensity towards the north-west in the region described in these pages. The greatest complication is reached in the oldest rocks, in the Vale of Towy, but there is reason to think that here, as in the ground further west, much of it is due to pre-Old Red Sandstone, and possibly pre-Silurian, earth-movements. These disturbances run nearly at right angles to the normal north-north-westerly faults, which cross this and other parts of the coalfield.

The glacial phenomena point to the glaciation of this part of Wales having been on a great scale. Not only were the main valleys leading southwards filled to overflowing, but there was pressure from the north sufficient to force the upper layers of the ice to leave the Towy Valley and to cross several points on its steep southern side, the highest parts of the Black Mountains alone effectually opposing the southward flow. These facts suggest the influence of a great mass of ice in Central Wales, in a region of which the glacial phenomena are imperfectly known.

Method of recording Fossils.

In view of the importance of the fossil evidence in mapping the subdivisions of the older Palæozoic rocks, a method has been devised whereby the locality, collector, and destination of every specimen have been recorded. The method is explained on p. 14.

CHAPTER II.

CAMBRIAN ROCKS.

TREMADOC SERIES.

Peltura punctata Beds.

BY H. H. THOMAS.

The oldest rocks met with within the area illustrated in the map make their appearance to the south and south-west of Llanarthney, between the River Towy and the Silurian and Old Red Sandstone. There the Tremadoc rocks are brought up suddenly along the axes of faulted anticlines which form part of a series of folds involving also the next higher series of rocks. These folds are the minor flexures of an anticlinal system which, taken as a whole, has an east-north-easterly pitch, and the axis of which runs in a west-south-westerly direction to the edge of the map. That is to say, the axis of this anticlinal system is parallel to the main strike-faults and folds of the district (p. 185).

The base of the Tremadoc rocks has not been seen and the top is far from a definite line, as there is an actual passage into the overlying Arenig deposits. The Tremadoc Beds consist, for the most part, of dark shales, soft and uncleaved blue mudstones, and occasional dark-blue conglomeratic grits which occur more frequently towards the upper limit of the series.

The shales and mudstones are fairly fossiliferous and yield trilobites, lamellibranchs, and an *Orthoceras*. Among the first-named the genus *Peltura* is characteristic of these deposits, the prevailing species being *Peltura punctata*, Crosfield and Skeat. For a complete list see p. 227.

It is evident that we are dealing with an easterly extension of the Tremadoc rocks described by the Misses Crosfield and Skeat* in the Carmarthen district, where also they are characterised by the species of *Peltura* mentioned above. They were considered by these authors to be the probable equivalents of some part or parts of the Scandinavian Stage *3a* of Brögger,† which he correlates with the Shineton Shales; and they point out that the presence of *Orthoceras* in the lowest beds would exclude the existence of $3a^{\alpha}$. In the Llanarthney district the same is probably true, for there also *Orthoceras* occurs in the lowest beds.

As these deposits are particularly poor in forms it is almost impossible to say how much of the Tremadoc Series is represented, but it is certain that there is a more or less perfect passage into the overlying Arenig rocks.

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* *Quart. Journ. Geol. Soc.* vol. lii, 1896, p. 523.

† Brögger, 'Die Silurischen Etagen 2 und 3 im Kristianiagebiete,' 1882.

In the bed of the Ffinnant, one-and-a-half miles south-west of Llanarthney, for a distance of about 350 yards, opposite the farm of Cwm-du, there is a good section in blue mudstones and shales with interbedded pebbly grits. About 150 yards down the stream from the farm the beds are much disturbed and are thrown into several small folds ; it is probable therefore that at this point there is a fault which separates them from the Arenig rocks to the north (p. 14).

The blue mudstones opposite the farm-house dip south-east at 60°, and have yielded *Peltura punctata*, C. and S., and *Orthoceras perannulatum* ? Portl. [Cwm-du, Carm. 40 NE. W λ 1, H.T. 96–100]. At a point 200 yards up the stream from the farm the dip is reversed and here again the Tremadoc rocks are faulted off from the higher beds.

The mudstones of Cwm-du continue in their south-westerly strike and crop out in the high road-bank 300 yards north-west of the junction of the branch-road from Bryn-hawddgar with the main road to Porth-y-rhyd.

A mass of shales and mudstones of the same age and lithological character occurs half a mile to the north of the rocks already described, and has a parallel strike. It is faulted on its southern side, but to the north passes upwards into a series of grits and conglomerates which are considered to be of Arenig age.

This strip of mudstones is not well exposed within the limits of the map, but may be well seen in a dingle just beyond its western edge. In this dingle 250 yards to the east of Pen-y-banc-isaf Farm* the mudstones yielded *Peltura punctata*, C. and S.†, *Ogygia marginata*‡, C. and S., and *Orthoceras perannulatum* ? Portl. [Pen-y-banc-isaf, Carm. 40 NW. E λ 4, H.T. 18–21, 37–45].

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* 'Summary of Progress' for 1903, p. 32, *Mem. Geol. Surv.*

† Field determination; specimens not brought away.

‡ The work of the Survey in the district to the west of this sheet has established the fact that shales which are lithologically and palæontologically equivalent to the *Ogygia marginata* Beds of Crosfield and Skeat (p. 14) are exposed at Henllan Amgoed, north of Whitland.

Salter's description and figures of *Asaphus ? (Basilicus) hybridus* were based on two specimens (pygidia) obtained from this locality and preserved in the Museum at Jermyn Street. It therefore seemed probable that *Ogygia marginata*, C. and S., described in 1896, from the Carmarthen district, would prove to be Salter's *Asaphus* [or *Ogygia*] *hybridus*. (*See* Salter, 'Monograph of the British Trilobites,' 1864–1883, p. 153 and pl. xxiii, figs. 8 and 9, *Palæontograph. Soc.*)

Specimens of *O. marginata* have since been submitted to Mr. P. Lake, who has compared them with Salter's types from Henllan Amgoed. He is of the opinion that *O. marginata* and *A. hybridus* are identical, but that both must be referred to *O. selwyni*, Salt.

CHAPTER III.

ORDOVICIAN ROCKS.

By T. C. Cantrill and H. H. Thomas.

Introduction.

The 'Lower Silurian' [Ordovician] rocks of the north-west part of the district were represented by Murchison on the map which accompanied his *Silurian System* (1839) as consisting of Llandilo Rocks (flags and limestones), in which the chief bands of limestone were picked out by colour. The Llandilo group is shown as bounded on the south-east, between Llangadock and Llandilo, by the grits of Carn-gôch, Careg-cegyn, and Ffairfâch, which he regarded as Caradoc rocks. On the north-west it was represented as underlain by 'Cambrian' beds extending from the Vale of Towy towards Central Wales. Murchison was thus under the impression that there was a descending sequence from south-east to north-west: but as he failed to find his supposed Caradoc rocks farther to the south-west than Llandilo, he assumed that the sequence in that direction became incomplete.

His sections* show the same structure, the ridge of Carn-gôch being represented as Caradoc Sandstone dipping away from the Llandilo Flags of the Vale of Towy and towards the 'Upper Silurian,' though at the same time they suggest the presence of an anticline in the Llandilo Flags of the Towy Valley.

In Chapter 28 the same theory of the structure is brought out; after stating that south of Llangadock a zone of Caradoc Sandstone is interpolated between the Llandilo Flags and the 'Upper Silurian' Rocks, he traces the same sandstone to Tre-gîb (Llandilo) where he speaks of it as overlying Llandilo Flags at a high angle,† and remarks that similar sandstones are found at Golden Grove, highly inclined, dipping under a thin zone of the 'Upper Silurian' and passing downwards into black trilobite flags. In all cases he correlates these sandstones with the Caradoc Sandstones of Shropshire. Proceeding westwards he surmised that certain sandstones and fine conglomerates [Arenig] at Glasgoed near Llanarthney might be referable to the same horizon.

He considered that the Llandilo Flags passed downwards at Llangathen and Grongaer into 'black schists' of his Cambrian System, but these 'black schists' have since been recognised to be of Bala age.

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* 'Silurian System,' 1839, pt. 2, pl. 34, figs. 5, 6, 7, and 8.

† *Ibid.*, pt. 1, p. 354.

The Geological Survey Horizontal Section (Sheet 3) by Ramsay, Phillips, De la Beche, and Aveline, published in 1844, showed the same general structure as was subsequently represented on the map; the line between the 'Upper' and 'Lower Silurian' was not clearly marked on the section; everything below the Old Red Sandstone being named 'Silurian Rocks.' In a later edition the junction of the 'Upper' and 'Lower Silurian' is shown as an unconformity; the Ludlow and Wenlock, Upper Llandovery, Llandilo, Caradoc, and Lower Llandovery are more or less distinguished by symbols.

The map of the Geological Survey (Sheet 41) surveyed by De la Beche, Phillips, and Ramsay, and published in 1845, with additional lines by Aveline in 1855–6, set right most of the points wherein Murchison's pioneer work had been in error. The Llandilo Flags are shown and some of the limestones picked out, but the Carn-gôch, Careg-cegyn, and Ffairfâch Grit is represented as lying within and not at the base of that subdivision, the true base of which was apparently not recognised. It was, however, seen that the beds to the north-west of the Llandilo Flag outcrop are of later date, and though the boundaries were not traced the rocks were indicated by symbols as being Caradoc and Lower Llandovery, probably on the evidence of fossils collected during traverses into the country north of Llandilo.

But beyond the fact that the 'Upper Silurian' rests directly on the Llandilo Flags along the south side of the Vale of Towy, whereas on the north side a great thickness of newer 'Lower Silurian' and Lower Llandovery Beds succeeds the Flags, the unconformities and faulting of the district were not brought out.

Sheet 13 of the Geological Survey Vertical Sections illustrates the rocks in the Golden Grove district from the Tilestones to the 'Lower Silurian' strata, as identified by John Phillips. In it may be recognised the horizons of the Ffairfâch Grit, the chief limestone group of the Llandilo Flags, and certain details in the 'Upper Silurian' rocks, but folds and faults were not taken into account. De la Beche made use of the details of this section in Vol. I of the Memoirs of the Geological Survey, but employed no group-names, and did not indicate the localities of the exposures, which makes the interpretation difficult. It is possible, however, to identify the Ffairfâch Grit, the Llandilo Flags, and the 'Upper Silurian' grits and tilestones. He notices the fact that the 'Upper Silurian' sediments, though largely calcareous in Shropshire, are here chiefly arenaceous,* and that there is an overstep at the base of the Old Red Sandstone west of Llandilo.†

He observed that some 600 feet of grits and sandstones, chiefly red [Trichrûg Beds] underlie the Tilestones near Llangadock,‡ and rightly included them in the Silurian System.

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* *Mem. Geol. Surv.*, vol. i, p. 41, 1846.

† *Ibid.*, pp. 24, 44, 45

‡ *Ibid.*, pp. 46, 50.

Phillips * records numerous fossils from localities in South Wales, and we have embodied many of his results in the following pages.

In 1879 Lapworth † recorded from the Llandilo Shales [*D. bifidus* Beds] of 'Pwllacca,' near Llandilo [—Pwll-llacca of the old one inch map, Sheet 41 ; Troed-y-rhiw, on the Breinant, 1½ miles east of Llandilo, on the six-inch map, Carm. 33 S.E.], small varieties of *Didymograptus murchisoni*, with *Diplograptus foliaceus* and *Climacograptus cælatus.*

M'Coy obtained the following types and figured specimens from the Llandilo beds of the neighbourhood of Llandilo :—

Hyalostelia fasciculus, from Tregîb, Llandilo.
Leptæna tenuissime-striata, from Llandilo.
Lingula obtusa ? *Hall*, from Llandilo.
Calymene baylei, from Tregîb, Llandilo.

The above specimens are preserved in the Sedgwick Memorial Museum at Cambridge.

The following subdivisions of the Ordovician system are shown upon the map :—

		Ft.
Bala Series	Slade and Redhill Beds - - - - - -	—
	Bala Limestone, about - - - - - -	200
	Dicranograptus Shales - - - - - - -	—
Llandilo Series	Llandilo Flags and Limestones, about - -	2,500
	Ffairfâch Grit - - - - - - - - -	150
Arenig Series	Upper ; *D. bifidus* Beds, at least - - -	400
	Middle and Lower ; *Ogygia marginata* Beds, seen to - - - - - - - - -	1,500

The Arenig rocks of this area may be separated into two well-marked subdivisions :—

Upper Arenig characterised by graptolites of the *Didymograptus bifidus* type.
Middle and Lower Arenig characterised by the trilobite *Ogygia marginata.*

As the shales with *Didymograptus bifidus* are now classed as Upper Arenig,‡ the *Ogygia marginata* Beds which lie between this zone and the Tremadoc may be regarded as representing Middle and Lower Arenig deposits.

Surrounding the outcrops of Tremadoc rocks described on p. 6 is a series of blue mudstones, iridescent dark shales and conglomeratic grits. These beds occupy the north and south flanks of the main anticline (p. 185), and the synclinal areas between the masses of Tremadoc rocks (Fig. 1 p. 11). They are much faulted and folded, and it is impossible to obtain anything like a true impression of the structure of the rock-masses taken as a whole, from a consideration of isolated dips and exposures. They present many points of similarity to the Tremadoc rocks, and *Ogygia marginata* with several other fossils are common to the two formations, but this division of the

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* 'The Malvern Hills, etc.,' *Mem. Geol. Surv.*, vol. ii, pt. 1 (1848).

† *Ann. Mag. Nat. Hist.*, ser. 5, vol. iv, 1879, p. 333.

‡ G. L. Elles, *Geol. Mag.*, 1904, p. 199.

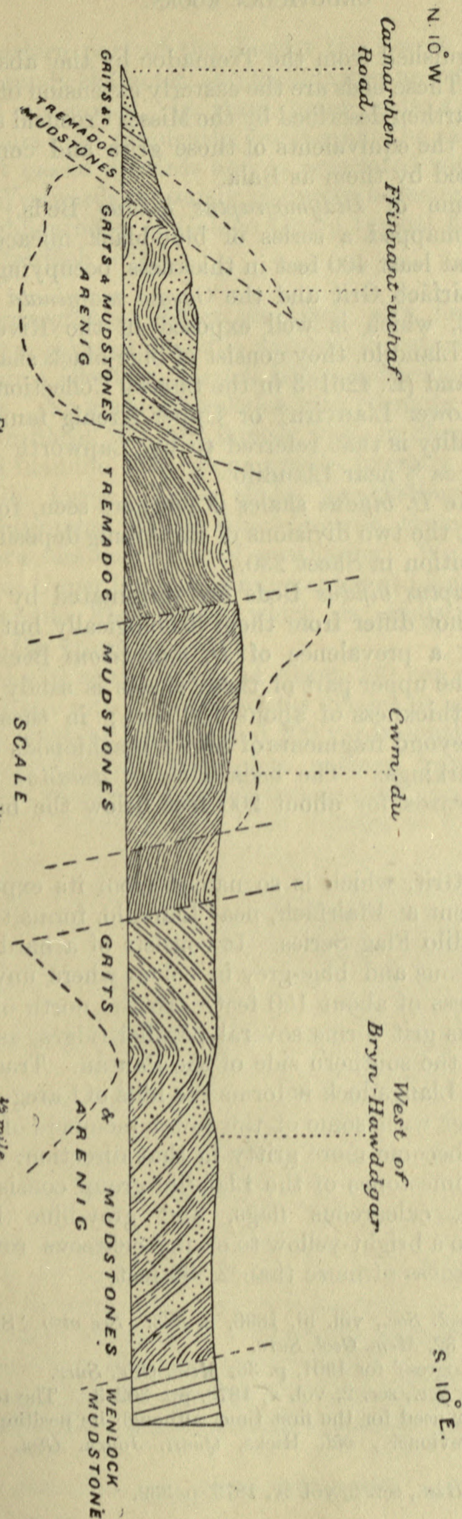

FIG. 1.—*Section through Tremadoc and Arenig Rocks near Llanarthney.*

BY H. H. THOMAS.

Arenig is distinguished from the Tremadoc by the absence of the genus *Peltura*. These beds are the easterly extension of the Arenig rocks near Carmarthen described by the Misses Crosfield and Skeat,* and include also the equivalents of those grits and conglomerates which were classed by them as Bala.

Under the name of *Didymograptus bifidus* Beds,† has been recognised and mapped a series of blue-black micaceous shales and mudstones, at least 400 feet in thickness, occupying a position between the Ffairfâch Grit and the *Ogygia marginata* Beds. In their lower part, which is well exposed in the River Breinant (Sheet 212) near Llandilo, they consist of blue-black shales with an occasional ash-band (E. 4261–3 in the Survey Collection), and contain a typical Lower Llanvirn‡ or Upper Arenig fauna (p. 227).

The above locality is that referred to by Lapworth under the name of 'Pwllacca'§ near Llandilo.

The base of the *D. bifidus* shales is nowhere seen, for although lower beds occur, the two divisions of the Arenig deposits are never seen in juxta-position in Sheet 230.

The *Didymograptus bifidus* Beds are terminated by blue-black shales which do not differ from them lithologically but which are characterised by a prevalence of *D. murchisoni* Beck sp., var. *geminus*, His. The upper part of these shales is sandy and micaceous, and has a thickness of about 150 feet; in these we have found no fossils beyond fragments of horny brachiopods (*Lingula*?) and fucoidal markings. The beds with *D. geminus* thus seem to extend downwards for about 200 feet below the base of the Ffairfâch Grit.

The Ffairfâch Grit, which is so named from its exposure and typical development at Ffairfâch, near Llandilo, forms the natural base to the Llandilo Flag Series. It consists of a hard yellowish sandstone, calcareous and blue-grey in colour where unweathered, and has a thickness of about 150 feet. To the north of the map (in Sheet 212) this grit forms several parallel ridges, as at Cwm-Cîb-canol and on the southern side of the Pantau. Traced north-eastward towards Llangadock it forms the hills of Careg-cegyn and Carn-gôch, together with some of the lower members of the Llandilo Flags which become more gritty in that direction.

The flags and limestones of the Llandilo group consist of blue, brown-weathering, calcareous flags, and grey-blue limestone, which weather into a bright-yellow to orange ochreous rottenstone. They have a thickness of more than 2,500 feet.

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* *Quart. Journ. Geol. Soc.*, vol. lii, 1896, p. 523. *See also* 'Summary of Progress' for 1903, p. 32, *Mem. Geol. Surv.*

† 'Summary of Progress' for 1901, p. 36, *Mem. Geol. Surv.*

‡ Hicks, *Pop. Sci. Rev.*, ser. 2, vol. v, 1879, pp. 302–3. The term 'Llanvirn' is in this paper used for the first time, although its position had been partially defined previously, *vide* Hicks, *Quart. Journ. Geol. Soc*, vol. xxxi, 1875, p. 167.

§ *Ann. Mag. Nat. Hist.*, ser. 5, vol. iv, 1879, p. 339.

In the eastern part of the district the lowest 300 feet have a much more sandy character, and include grey and pebbly sandstones and sandy mudstones. In these lower beds *Asaphus tyrannus*, Murch., occurs most frequently, but it cannot be said to characterise them, for it passes upwards and is associated with *Ogygia buchi*, Brongn. Westwards the sandy character becomes less marked and in the neighbourhood of Golden Grove typical flags rest directly upon the Ffairfâch Grit.

The *Dicranograptus* Shales are black, soft, fissile shales which succeed the uppermost Llandilo flags and limestones without break. They contain a Glenkiln-Hartfell fauna and belong to the Llandilo-Bala Series. No graptolitic shales with Glenkiln forms have been met with in Sheet 230, but farther west, in Sheet 229, the upper part of the Llandilo Flag group passes laterally into shales yielding Glenkiln forms. These shales are distinguished also from the *Dicranograptus* Shales which overlie them by their lithological characters and mode of weathering. We therefore suppose that the true Upper Llandilo is represented at Llandilo by some part of the Llandilo Flag Group which is indistinguishable from the rest of the group below it.

Nowhere within the limits of Sheet 230 can the passage from Llandilo Flags into *Dicranograptus* Shales be seen, but in Sheet 212, to the north of Llandilo and 200 yards south of Crûg (p. 31), a small dingle shows a complete passage from brown-weathering Llandilo Flags into black *Dicranograptus* Shales with abundant specimens of *Diplograptus*. This passage is probably best seen in a small quarry north of Ty-newydd Farm at Nantgaredig (Sheet 211), in the southern side of which a dark flaggy limestone of Llandilo Flag age is succeeded normally by black graptolitic shales, the lower part of which is probably referable to the Upper Llandilo or Glenkiln.

These black shales pass up into a development of Bala Limestone similar in all respects to the Shoalshook Limestone of Marr and Roberts,* but as the complete sequence from Llandilo to Bala Limestone is nowhere seen it is impossible to estimate their total thickness. Somewhere near the middle of the black shales, or perhaps higher, occurs a dark shaly limestone, full of *Orthis*, which is shown on Dryslwyn Castle Hill (Fig. 4, p. 29), and also to best advantage on the north of the Cincoed Ridge (Fig. 5, p. 34). It is too far removed from the horizon of the Bala Limestone to be considered the equivalent of the Robeston Wathen Limestone of Marr and Roberts, although lithologically it resembles it. We must therefore regard it as a calcareous horizon in, and not at the top of, the black *Dicranograptus* Shales.

The Bala Limestone of this district consists of a dark-grey crystalline and often crinoidal sandy limestone easily distinguishable from those in the Llandilo Flag Group or in the *Dicranograptus* Shales. At Crûg, Llandilo (p. 31), it contains small nodules which Dr. Pollard finds to be phosphatic. It is abundantly fossiliferous, and in palæontological character coincides exactly with the Shoalshook Limestone* of Pembrokeshire.

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* *Quart. Journ. Geol. Soc.*, vol. xli, 1885, p. 480.

Immediately succeeding the Bala Limestone occurs a group of blue-grey mudstones and shales which are lithologically distinct from all other deposits of Ordovician age present within the district. These are the beds which were recognised by Marr and Roberts in the Haverfordwest area as succeeding the Shoalshook Limestone, and to which they gave the name 'Redhill Beds.'

For the determination of most of the trilobites from the Lower Palæozoic we are indebted to Mr. Philip Lake, M.A., F.G.S., and of the graptolites to Miss E. M. R. Wood, D.Sc. In the lists included in these pages the identifications due to these authorities are distinguished by the letters (L.) and (W.). All other identifications have been made by the palæontologists to the Survey. The references in square brackets indicate (1) the locality entered in the Survey Catalogue, *e.g.*, Pont-ar-ffinnant; (2) The quarter-sheet of the six-inch maps, *e.g.*, Carm. 40 NE.; (3) the number of the locality in that map, *e.g.*, W λ 5; and (4) the numbers of the fossils on the collector's list, *e.g.*, J.P. 3656–3686. The localities are indicated exactly on the MS. copies of the six-inch maps deposited in the Geological Survey Office. For a complete list of Ordovician fossils from Sheet 230, see pp. 227–229.

T. C. C. and H. H. T.

ARENIG SERIES.

Ogygia marginata Beds.

This series of rocks is well exposed to the south-west of Llanarthney. Southwards from Pont-ar-ffinnant, on the main road from Llandilo to Carmarthen, the Ffinnant shows a good section in mudstones and iridescent shales which are fossiliferous. The dip gradually changes from north to north-east, showing how the beds wrap round the Tremadoc rocks which stretch from Ffinnant-uchaf Farm to the edge of the map. In this part of the section which has a length of about 200 yards the following fossils have been collected :—*Ogygia marginata*, C. and S. (L.), *Olenus* (sensu lato) (L.), *Orthoceras* sp., *Lingula* sp., *Obolella* sp., *Hyolithus* sp. [*Theca*, Auctt.]. [Pont-ar-ffinnant, Carm. 40 NE. W λ 5, 6, 7, J.P. 3656–3686]. The *Olenus* is from λ 5, which may be on a small strip of infolded Tremadoc Rocks.

At a point 250 yards from the bridge the dingle of the Ffinnant is crossed by the fault which forms the southern limit of the Ffinnant-uchaf Tremadoc rocks. Southwards the Arenig deposits are chiefly conglomeratic grits with thin interbedded mudstones which occupy the bed of the stream as far as the Tremadoc exposures of Cwm-du (p. 7). At 350 yards to the south of Pont-ar-ffinnant the dingle divides and discloses a well-marked anticline which is one of the many minor folds affecting these rocks. From the Tremadoc rocks of Cwm-du southwards the same series of grits and conglomerates is met with, and except for minor folds has a general southerly dip. The conglomerates are well exposed at Wern and Glasgoed-isaf (p. 8), and to the east at Clôs-glâs. On the northern side of the anticlinal ridge of Cwm-du they are best seen near the site of the old Llanarthney Vicarage and at several points between that locality and the Ffinnant. These conglomerates contain fragments ranging up to an inch or more in diameter, and are fairly coarse deposits. The well rounded pebbles of which they are composed are set in a blue felspathic matrix which is highly characteristic; among the rocks represented in the form of pebbles occur quartzites, rhyolites, jaspers, quartz-schists, sheared fine sediments, and many other types of rock indicating that some old land-area containing volcanic and dynamically metamorphosed rocks was undergoing denudation. Mudstones similar to those of Pont-ar-ffinnant overlie the southern mass of grits and conglomerates at Arbont, to the south of Llanarthney; the uppermost conglomerate occurs under Arbont Cottage and a section down the stream shows the soft beds for a distance of 200 yards. At this point the mudstones are much disturbed, reversed in dip and faulted against steeply inclined Wenlock rocks. This stream-section yielded *Ogygia marginata*? C. and S., and *Redonia anglica*, Salt. sp. [Arbont, Carm. 40 NE. W λ 2, H.T. 101–104].

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* Marr and Roberts, *Quart. Journ. Geol. Soc.*, vol. xli, 1885, p. 480.

The mudstones may be traced as a belt 200 yards wide from Arbont Dingle to Bryn-Hawddgar. A small quarry, in which they are vertical, has been opened to the south of the road 300 yards north-east of Bryn-Hawddgar, but has yielded no fossils.

Some of the pebbles from the conglomerate at Arbont mentioned above have been sliced and consist of a fine-grained quartzite and a rhyolite with well-defined flow-structure (Specimens E. 4178 and E. 4179 of the Survey Collection).

H. H. T.

Didymograptus bifidus Beds.

The most easterly exposure of these shales is afforded by a brook 250 yards west of Llwyn-bedw, north of Trapp. On going north-westwards, down stream, green Silurian mudstones crop out at a small ruined building and continue for several yards; where last seen they dip gently southwards. Against them, black shales, some soft, others sandy and micaceous, stand in a vertical position. The junction, however, is not actually visible, but can be located to within a yard; its direction strikes S. 20° W. The black shales, generally vertical, and striking about S. 30° W.

but rolling in strike and in dip, and exhibiting small overfolds, are continuously exposed down stream. They yield occasional fragments of a *Lingula* and markings which resemble 'fucoids' or worm-tracks, but no graptolites, and thus agree with other sections, as at Ffairfâch. At 60 yards down stream from the Silurian junction the stream turns slightly to the west and the *D. bifidus* Beds pass in a few feet into the Ffairfâch Grit which at its base contains an abundance of *Orthis* (*Dalmanella*) *testudinaria*, Dalm. A few yards south-west of this section the base of the grit runs into the Silurian boundary and cuts off the *D. bifidus* Beds.

On the north side of the Cwm Cîb syncline they rise from beneath the Ffairfâch Grit on the east bank of the River Cennen at Ffairfâch Station. The upper unfossiliferous part is well exposed on the eastern side of the valley, while the softer shales below crop up in the river-bed 350 yards below Pont Gwladys (Pont Ladies).

This section has yielded the following fossils [250 yards north-east of Ffairfâch Railway Station, Carm. 41 NE.E λ 12, T.C.C. 237–277]:—

Asaphus tyrannus, *Murch.*
Ogygia *cf.* corndensis, *Murch.* sp
Trinucleus *cf.* ramsayi, *Hicks*
Trinucleus n. sp.
Lingula hawkei, *Rouault*
Lingula sp.
Monobolina plumbea, *Salt.* sp.
Siphonotreta micula, *M'Coy*

Climacograptus *cf.* confertus, *Lapw.* (W.).
Didymograptus acutidens, *E. and W.* (W.).
Didymograptus artus, *E. and W.* (W.).
Didymograptus patulus ? *Hall* (W.).
Didymograptus *cf.* stabilis, *E. and W.* (W.).
Nemagraptus ? (W.).

The section in the River Breinant mentioned on pp. 10 and 12 yielded the following [Sheet 212, Carm. 33 SE. E λ 4 and 5, Carm. 34 SW. W λ 3 and 4, T.C.C. 400–432]:—

Ampyx salteri ? *Hicks*
Ampyx sp.
Barrandia sp.
Calymene hopkinsoni ? *Hicks*
Ogygia selwyni ? *Salt.*
Phacops llanvirnensis, *Hicks*
Palæarca ?
Hyolithus sp. [Theca, *Auctt.*]

Climacograptus *cf.* confertus, *Lapw.* (W.).
Climacograptus sp. (W.).
Didymograptus artus, *E. and W.* (W.).
Didymograptus murchisoni, *Beck* sp. [geminus-type] (W.).
Didymograptus murchisoni, *Beck* (W.).
Didymograptus stabilis, *E. and W.* (W.).

No more sections are seen till we reach a pistyll 80 yards north-west of Cwrt-y-gorphwys Cottage (half-a-mile south-west of Ffairfâch); here, soft black shales and mudstones, seen only for a thickness of 3 feet, yielded no fossils, and consequently their identification is open to doubt. If they are *D. bifidus* Beds they must be separated from the Llandilo Flags exposed a few yards farther east in the path leading up to the cottage by a fault, which is suggested by their disturbed condition also.

At Cwm-du Farm (p. 20) a dingle running north-westwards towards the Brick and Tile Works affords a good view of the beds from the Ffairfâch Grit, through the sandy micaceous shales, down into the soft graptolitic shales and mudstones which dip a little east of south at 45°. The same sequence is again exposed in a dingle 100 yards east of Parklane Lodge on the eastern side of Golden Grove Park; it is questionable however, if the uppermost beds which appear to rise from beneath the Ffairfâch Grit are really the highest—some few feet may be squeezed out. By working up stream in a southerly direction we ascertain the existence of a sharp syncline in the grit, from the south side of which a few feet of pale-blue soft mudstones, sparry and slickensided, emerge; these are probably referable to the *D. bifidus* Beds, but they are cut off almost immediately by the Silurian boundary.

T. C. C.

The shales are well exposed in a dingle above the bridge which carries the drive to Golden Grove House, but they are much crushed, owing to the proximity of a fault which runs along the western side of the dingle for some distance. Near the head of the dingle the fault turns westward, and passes about 150 yards to the south of Golden Grove House, bringing up a minute patch of these beds between the Llandilo Flags and the Silurian rocks.

The above fault shifts the outcrop 180 yards to the north, on to the steep slope north of Golden Grove House. Here they present the sandy micaceous type characteristic of the upper part of this subdivision. They may be traced as far as the keeper's lodge at Llanfihangel Aberbythych where they pass under a thick covering of boulder clay. A fault which passes a little to the east of the lodge displaces these beds at least 280 yards to the south, as may be ascertained in a stream which flows down from the Silurian rocks 200 yards north-west of Llanfihangel church. They dip about S. 20° E. at 70°, and contain abundant graptolites.

About 100 yards to the west of this stream the shales are thrown to the north by a fault which leaves the base of the Silurian and runs in a north-westerly direction towards the cottage called Elusendy, situated on the Llandilo road. This fault, with its fault rock, is visible in the entrance to a deep dingle which forms the eastern edge of Carbury Mount. The fault-rock makes a small angle with the vertical, and hades in a south-westerly direction.

From the point where this fault crosses the dingle there is a good section for about 100 yards southwards, in fine black shales, dipping south at 60°, followed by the sandy micaceous beds, 150 feet thick, which occur above the graptolite shales. The dingle ends in a cascade on the grit. The lower soft shales yield graptolites in a good state of preservation, amongst which *Didymograptus bifidus*, Hall (approximating *D. geminus*, His.) is abundant, with an occasional specimen of *D. bifidus*, Hall sp. [Tan-yr-allt, Carm. 41 NW. E λ 1, H.T. 1–5]. The above were identified by Miss E. M. R. Wood.

The shales continue their westerly strike along the northern side of Carbury Mount, and their upper sandy part is exposed for 200 yards in a cutting on the branch-road leading from the main road to Llanfihangel. At the western end of the hill a path to a farm called Pant-glas crosses this branch road, and at this point the sandy shales are seen at a spring. The path southwards passes on the east a quarry in the Ffairfâch Grit (p. 20) and on the north an old quarry in Llandilo Flags (p. 27), at the northern end of which the black shales may be seen faulted against the flags. The line of this fault is marked by a striking change of slope and by the presence of a strong spring, where the flags are thrown against the impervious black shales. The strong feature which accompanies this boundary-fault of the black shales bends round between Pant-glas Farm, and the dingle 150 yards to the west.

In the dingle they are well exposed for about 150 yards, but are much crushed as might be expected, for the fault displaces them at least 300 yards in a horizontal direction.

Westwards these beds pass beneath a thick deposit of boulder-clay which covers the gentle slope between the Silurian ridge and the alluvium of the Towy, and they are not seen again except for a small exposure at Troed-y-rhiw Inn. Black shales were noticed immediately behind the inn in the lane leading southwards. Here also they are much crushed and give place in a few yards to the Silurian rocks. Still further west we may suppose that these shales sweep round on both sides of the Llanarthney anticline (p. 185), and pass to the south below the Silurian rocks and to the north into the disturbed ground under the Towy.

H. H. T.

On the north side of the alluvial flat of the Towy in Sheet 212 the *Didymograptus bifidus* Shales occupy a strip of country about a mile long by half a mile wide. They range from the Heronry in Dynevor Park on the east to about half a mile west of Cilsân, and stretch northwards towards Glandwr and Birdshill Farms. They consist as usual of fine black micaceous shales and mudstones, with associated thin ash-bands, and present the same general lithological characters as they do in the River Breinant (p. 12).

They are faulted on the northern and eastern sides against Llandilo flags and limestones to the elimination of the Ffairfâch Grit and probably some of the associated beds. The faulted junction is well seen at the Heronry in a stream at a point 230 yards east of Pen-y-banc Farm, and the shales to the immediate south have yielded characteristic graptolites of the *Didymograptus bifidus* type. [Parc-llwyn, Carm. 33 SE. W λ 7, J.P. 4647–4653].

T. C. C. and H. H. T.

LLANDILO SERIES.*

Ffairfâch Grit.

The Ffairfâch Grit enters the map north of Llwyn-bedw Farm, and is exposed in the stream (p. 16). Its junction with the underlying *D. bifidus* Shales crosses the stream at a distance of 60 yards down stream from the Silurian junction (and 250 yards north-west of Llwyn-bedw) and strikes S.30°W. The lowest beds of the grit, into which the *D. bifidus* Shales pass in a few feet, are soft and contain numbers of *Orthis testudinaria*, Dalm., as identified by Mr. E. T. Newton. [Llwyn-bedw, Carm. 42 NW.W λ 6, T.C.C. 442–443].

A few yards farther down stream more massive tough grits are exposed, dipping E. 40° S. at high angles; a few yards farther on they dip W. 40° N. at high angles, and strike towards Maes-y-fallen. The brook then passes into Coed Cwm Cîb Faenol; just within the wood, grit is seen dipping W. 35° N., and still higher beds are exposed for some yards farther down stream. Beyond this point the stream passes off the massive grit (Ffairfâch Grit) onto softer beds which may be regarded as the basement-beds of the Llandilo Flags (p. 22). From this section it appears that the lowest beds of the Ffairfâch Grit are inverted, and that the true ascending succession is from south-east to north-west.

A low ridge running westwards across several fields conducts us to Maes-y-fallen, where the grit with a true dip of 115° in a north-westerly direction, but an apparent dip to the south-east of 65°, is exposed at the south-east end of the house. From another exposure 50 yards to the south-west of the house the following fossils were obtained: *Asaphus powisi*, Murch., *Orthis patera* ? (Salt. MS.) Dav., *O. vespertilio*, J. de C. Sow. sp., *Modiolopsis* ? [Carm. 41 NE. E λ 11, T.C.C. 340–348]. They have been determined by Mr. E. T. Newton.

Beyond this point the grit presumably runs into the base of the Silurian rocks. It does not reappear on the south side of the Cwm Cîb syncline till we reach Parklane and Garn-wen Farms, west of the Cennen. Here the grit forms a conspicuous ridge on the south side of the Llandilo-Llanelly road a few yards south of the second milestone from Llandilo, dipping a little west of north at angles varying from 70° to 30°. The ridge is presumably cut off on the west by a north-north-west fault having an easterly downthrow; and reappears as a sharp syncline in the dingle east of Parklane Lodge (p. 17). Here the grit overlies a few feet of shales referable to the *D. bifidus* Beds, and contains some distance above its base a thin band of dark impure limestone. A much less thickness of grit appears to crop out north of the synclinal axis than to the south of it, and some of the beds may be squeezed out. This syncline appears to be the western end of the Cwm Cîb syncline.

The northern limb of the syncline enters the map at Ffairfâch. The lowest beds are seen on the eastern side of the valley opposite the station, but are better exposed in the railway-cutting. The section begins immediately south of the level-crossing (Fig. 2, p. 21).

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* This spelling is adopted in place ot the old form Llandeilo for the sake of conformity with the New Series Ordnance Maps.

			Ft.	In.
Ffairfâch Grit	1*b*.	Calcareous sandstone with shale bands; a band of shale 4 ft. thick over about 1 ft. of crushed pale shale lies at the bottom - - - -	19	0
	1*a*.	Grit, thickly-bedded, with bands of sandy micaceous shale (up to 1 ft.) near the bottom -	82	0
			101	0

The beds dip about south at 70°. The remainder of the section in the cutting will be found described under the head of Llandilo Flags on pp. 23, 24.

Farther west a poor exposure of yellow sandstone in the lane about 100 yards north-east of Pen-coed Farm presumably marks the position of the Ffairfâch Grit; it yielded *Pyritonema* (*Hyalostelia*) *fasciculus*, M'Coy sp., identified by Mr. E. T. Newton. [Pen-coed, Carm. 41 NE. Wλ 4, T.C.C. 352, 353].

The thin-bedded yellow sandstones exposed in the yard at Pen-coed Farm probably belong to the Llandilo Flag Series (p. 24), and there are no sections in the supposed outcrop west of Cwrt-y-gorphwys. The outcrop reappears, west of the supposed fault, at Cwm-du Farm; it begins somewhat abruptly to the north of Glan-Cennen Farm and a little farther west has been quarried on the south-east side of the main road; other exposures may be found north of Garn-wen Farm where the rock dips east of south at 45°. Here the outcrop is cut by a fault with westerly upthrow, the effect of which is to suddenly narrow the syncline on the west, as seen in the dingle east of Parklane Lodge. Beyond this point a single outcrop dipping east of south runs westwards into Golden Grove Park. T. C. C.

This grit occupies the head of a dingle, already referred to as the one which crosses the drive to Golden Grove (p. 17), and forms a ledge over which the stream falls. It may be traced westwards for about 100 yards, at which point it is cut out by the fault occurring on the western side of the dingle. It may, however, be picked up again on the other side of Golden Grove House, and is well exposed under the terrace in a quarry opened for building purposes by the Earl Cawdor. In this quarry it consists of a thick-bedded massive sandstone which dips S. 20° W. at 55°. Westwards it continues with the same strike, with a few small undulations, as far as the keeper's lodge, where it is cut out by the fault which throws the *D. bifidus* Shales into contact with the Silurian strata.

At the head of the dingle at the eastern end of Carbury Mount the grit again forms a waterfall, and immediately succeeds the soft sandy beds of the *Didymograptus bifidus* zone in which the dingle has been excavated. The hard rock, traced westwards, occupies a slight hollow on the northern flank of Carbury Mount and is shown in a quarry 300 yards north-north-east of Pantglas Farm. The quarry has been opened up along the strike and in it the beds

FIG. 2.—*Section on Great Western Railway south of Ffairfâch Station.*

BY T. C. CANTRILL.

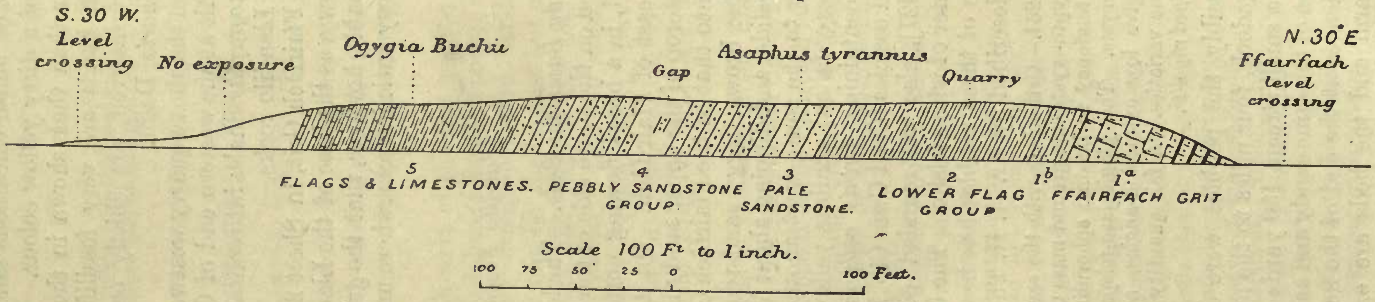
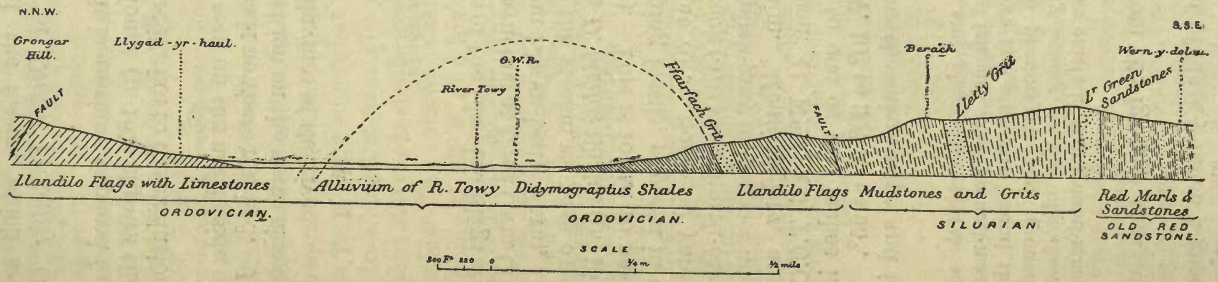


FIG. 3.—*Section across the Towy Valley at Golden Grove.*

BY H. H. THOMAS.



consist of bluish calcareous sandstones which weathers to a friable mass of a dirty yellow colour. Its calculated thickness is slightly greater than that shown in the quarry and amounts to 150 feet. Certain bands are very fossiliferous, and the fossils, which are badly preserved, are chiefly one species of *Orthis*, probably *O. testudinaria*, Dalm.

From the above quarry westward the grit is nowhere exposed for the fault at the western end of Carbury Mount (p. 187) throws the *Didymograptus* Shales into contact with the Silurian to the exclusion of the Llandilo rocks.

The Ffairfâch Grit, in Sheet 230, is not seen on the north side of the Towy, as the base of the Llandilo Series is nowhere reached. It is probable, however, that the grit has a position on the north side of the Towy anticline somewhere under the alluvium of the river.

H. H. T.

Llandilo Flags and Limestones.

Sandy Basement Beds.—The lowest beds of the Llandilo Flags are exposed on the south side of the Cwm Cîb syncline at Coed Cwm Cîb Faenol, in a brook flowing north-west from Llwyn-bedw Farm, 1¾ miles east of Ffair-fâch. On descending the stream we pass over the outcrop of the upper sandy beds of the *D. bifidus* Shales (p. 15) and onto that of the Ffairfâch Grit (p. 19). This is found to pass into fine brown flaggy sandstones containing fossils, exposed in a water-slide, and dipping about W. 35° N. at 70°. Some 50 yards farther to the south-west another little brook (370 yards north-east of Maes-y-fallen) exhibits yellow and purplish-grey mudstones and flags containing *Orthis calligramma*, Dalm., *Monticulipora*, and crinoid ossicles [Coed Cwm Cîb Faenol, Carm. 41 NE.E λ 6, T.C.C. 326, 327], also well-rounded pebbles up to one or two inches in diameter of white felsite. The beds dip W. 10° to 20° N. at 65°.

One of these pebbles has been sliced for the microscope and is thus described by Mr. H. H. Thomas :—

E. 4264.—Orthoclase with the sanidine-habit and plagioclase-crystals set in a crypto-crystalline ground-mass of quartz and felspar. The ground-mass has a tendency to become spherulitic and shows flow-structure round the phenocrysts. The plagioclase-felspars of both phenocrysts and ground-mass give low extinction-angles, and probably belong to the oligoclase-andesine varieties. A fair quantity of orthoclase exists in the ground-mass. *Devitrified rhyolite.*

Possibly the pebbles were derived from the igneous rocks of Llangadock, four miles to the north-east.

In a small stream 150 yards south-west of Maes-y-fallen a good section of the same sandy and ashy beds may be seen. The section commences at the end of the hedge running south-westwards from the farm and the beds are exposed down stream for 30 or 40 yards. The following details were obtained on working up stream from north-west to south-east :—

Stream 150 yards S.W. of Maes-y-fallen.

	Ft.	In.
Sandstone, brown, coarse-grained Sandstone, yellow, finer-grained, *Leptœna* ? Dip E. 40° S. at 70°	18	0
Gap of about	50	0
Sandstone, pale-buff and yellow (? ashy), thick and thin bedded, with pale green and white fragments, and pebbles of fine-grained quartzite. Dip vertical	12	0
Sandstone, yellowish-grey, soft, thin-bedded, with *Orthis*. Dip E. 25° S. at 80°	12	0
Sandstone, dark-brown, soft, coarse and open-grained. Dip W. 25° N. at 80°	8	0
Sandstone, greenish-grey, fine-grained; *Asaphus tyrannus*. Dip vertical	6	0

The lowest bed probably corresponds in position with the trilobite-bearing bed in the Ffairfâch cutting (p. 24). The true upward succession appears to be from south-east to north-west; the beds being somewhat inverted.

In a small stream 170 yards south-west of the last section (and about 320 yards south-west of Maes-y-fallen) a small exposure under boulder-clay shows dark-grey and orange-coloured sandstone dipping E. 20° S. at a high angle; it may be the highest but one of the beds in the last section; the rock has yielded the following fossils, as identified by Mr. E. T. Newton:—*Leptœna tenuissime-striata*? M'Coy sp., *Orthis patera*? (Salt. MS.) Dav., *O. vespertilio*, Sow., *Pyritonema* (*Hyalostelia*) *fasciculus*, M'Coy sp., and a monticuliporoid. [Maes-y-fallen, Carm. 41 NE.E λ 9, T.C.C. 332–334].

Beyond this section the sandy beds at the base of the Llandilo Flags are not again seen on the south side of the Cwm Cîb syncline, but on the north side they are well exposed in the Ffairfâch cutting, where the following details in descending order were obtained. The measurements begin 50 yards north of a level-crossing 270 yards south of Ffairfâch Station (Fig. 2).

Section in Great Western Railway south of Ffairfâch Station.

		Ft.	In.
5. Flags and Limestones (bottom) 108 Ft. 6 In.	Calcareous flags, blue-hearted, weathering brown, with yellow ochreous rottenstones averaging 2 inches in thickness but ranging up to 6 inches. Dip S. 5° E. at 68° to 70°. Some beds are entirely converted into rottenstones; some unaltered limestone-bands also occur (up to 6 inches), but sometimes these are represented solely by nodules in a mass of rottenstone. Limestones are more prevalent in the higher part of the section, the flags being more frequent in the lower part. Fossils abound in the flags at the base, and include *Asaphus tyrannus*, Murch., *Ogygia buchi*, Brongn., *Trinucleus lloydi*? Murch., *Orthis testudinaria*, Dalm., and *Favosites fibrosus*, Goldf. sp. [Ffairfâch Railway Cutting; T.C.C. 631–642]	36	6
	Calcareous flags as above, with a few thicker rottenstones near the bottom ranging up to 8 inches in thickness	18	0
	Gap in section	20	0
	Rottenstones, thick	13	0
	Rottenstones, thick, up to 1 ft., with flags at base	21	0

		Ft.	In.
4. Pebbly Sandstone Group 124 Ft. 6 In.	Decalcified sandstone, weathering yellow; pebbly, coarse, thin-bedded, without fossils. The rock is somewhat soft, the pebbles consisting chiefly of fine-grained quartzite, vein-quartz, etc., and white ash-like material	59	6
	Gap in section, presumably same as above	23	6
	Decalcified sandstone, more pebbly; pebbles are rounded and range up to half-an-inch; this rock passes down into a similar rock in which soft white pebbles (ash or felsite ?) are more abundant. There are some black shale partings and some rottenstones; a few fossils were noticed. The lowest bed forms a bold bluff jutting onto the railway. Dip 65°	41	6
3. Pale Sandstone 34 Ft.	Fossiliferous band	1	0
	White sandstone; at 18 ft. from the above bed it yielded fragments of *Asaphus tyrannus*, Murch., and brachiopods (compare beds 150 yards south-west of Maes-y-fallen, pp. 22, 23)	16	0
	Sandstone, greyer and containing occasional pebbles; signs of fracture at base	17	0
2. Lower Flag Group 112 Ft.	Calcareous flags, unevenly bedded, blue, bituminous; upper part concretionary, lower part changed into rottenstones; at base a 3 ft. band of rottenstone forming a gully	20	0
	Sandstone, grey, weathering yellow; fine-grained	4	6
	Shaly flags, containing nodular and bedded limestones up to 1 ft. thick	29	0
	Calcareous flags, thin and evenly-bedded, forming a large hollow (old quarry) in the section. Dip 70°	58	6

1. Ffairfâch Grit (p. 2).

In this section there is a group of 112 feet of flaggy beds immediately overlying the Ffairfâch Grit and underlying about 160 feet of ashy pale sandstones and pebbly sandstones. The flaggy group does not seem to be recognisable elsewhere. To the sandstone group are probably to be referred the sandy and ashy beds seen in Coed Cwm Cîb Faenol (p. 22) and in the yard at Pen-coed Farm (p. 20).

Some or all of the beds exposed in the cutting were open to view before the railway was constructed, and cropped out on the western side of the Cennen Valley near Pont Ladies, by which name the section was referred to by Phillips and other authors.

In 1866 Wyatt-Edgell* recorded *Lichas patriarchus*, Edgell, with *Asaphus tyrannus*, Murch., *Calymene cambriensis*, Salt., *Phacops* sp.,† *Proetus* n.sp. and *Trinucleus* n.sp. from the Pont Ladies quarry, which must have been in part of the above section. In 1867 the same author recorded *Ophileta* and *Lichas patriarchus*, Edgell, from Ffairfâch.‡

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* *Geol. Mag.*, 1866, p. 160.

† This is *Phacops conatus*, Salt. MS.

‡ *Geol. Mag.*, 1867, p. 113.

A little west of Ffairfâch the sandy basement beds of the Llandilo Flags are again exposed at Pen-coed Farm, where yellow thin-bedded grits dipping S. 5° E. crop up in the yard. No further sections are met with except a small exposure of yellow fine soft sandstone in a hedge-bank a few yards north of a pond at Garnwen Farm, 1½ miles south-west of Ffairfâch, on the axis of a syncline (probably a westerly prolongation of that underlying Cwm Cîb); the Ffairfâch Grit rises from beneath the sandstone on both north and south.

Flags and Limestones.—The river Cîb for some way above Tregîb House near Ffairfâch affords numerous sections of these beds, but opens up no great thickness as it closely follows the strike. The sections begin about 150 yards above Tregîb House, vertical calcareous flags cropping up in the bed of the river. Half-way up the right bank of the dingle a lane affords a section, at an old quarry, of thin-bedded blue impure limestones weathering to yellow rottenstone overlying dark brown shaly flags dipping S. 15° E. at 80° and yielding *Ogygia buchi*, Brongn. Doubtless it was this limestone belt which was represented on the old series map, Sheet 41. South of this quarry the beds in the stream form some cascades and show signs of disturbance. Slightly higher beds come in as we proceed up stream but they are much more weathered, and in a steep bank on the south side of the river a few yards below Cwm-Cîb Farm present a section of yellow ochreous rottenstone of great thickness; there are indications of synclinal folding with an east and west direction.

Still higher up stream brown rottenstones are exposed at 150 yards up a side-stream (200 yards west of Tir-mawr) flowing past Maes-Evan-isaf; they have yielded fossils which have been identified by Mr. E. T. Newton as *Calymene cambriensis*, Salt., and *Asaphus peltastes*, Salt. [Tir-mawr, Carm. 41 NE.E λ 7, T.C.C. 335–339]. At about 100 yards farther up the same side-stream (at 250 yards north of the Reservoir) rotten yellow flags yielded *Ogygia buchi*, Brongn., and *Trinucleus*. [Reservoir, 1 mile E. of Ffairfâch, Carm. 41 NE.E λ 8, T.C.C. 329, 330].

The next southern tributary of the Cîb, flowing past Tir-mawr Farm, shows for some yards above its mouth a good section in more or less decalcified flags, and at about forty yards above the Cîb, some orange-coloured rottenstones yielded the following fossils [100 yards north-west of Tir-mawr, Carm. 41 NE.E λ 2, T.C.C. 297–308] identified by Mr. E. T. Newton :—

Asaphus peltastes, *Salt.*
Asaphus tyrannus, *Murch.*
Calymene blumenbachi, *Brongn.*
Beyrichia sp.
Orthis vespertilio, *J. de C. Sow.*
Monticulipora lens, *M'Coy* sp.
Pyritonema (Hyalostelia) fasciculus, *M'Coy* sp.

At Troed-y-rhiw Farm, south-south-east of Ffairfâch, a small area occupied by the Flags is exposed between the drift and the Silurian rocks. Sections are afforded by a lane and by a brook, which come down together from the Silurian escarpment and pass by the side of the house. In the right bank of the stream, opposite the end of the fence which bounds the garden on the the south-east side, brown sandy rottenstones are seen striking east and west across the stream and dipping south at 50°; the beds gradually steepen when followed up stream, become vertical, and then dip at 70° down stream; at this point they yielded a specimen of *Ogygia buchi,* Brongn., identified by Mr. E. T. Newton [Troed-y-rhiw, Carm. 41 NE.E λ 13, T.C.C. 349]. A gap in the section of some 40 feet then follows; beyond it similar beds are seen, striking W. 10° S., and vertical, and exposed for a thickness of about 10 feet. Immediately afterwards the Silurian rocks come in (p. 43). The same stream at a point 100 yards west of the farm shows flags, from which *Trinucleus concentricus,* Eaton, var. *favus,* Salt., was identified by Mr. E. T. Newton [Carm. 41 NE.E λ 14, T.C.C. 331].

In the Cennen Valley south of Ffairfâch station, both the railway and also the river afford sections of the flags, all dipping south or a little east thereof. The best view of the beds is obtained at a limestone quarry on the east side of the river, near Maerdy; the beds dip south at 50° but the edges are turned over, presumably by ice-flow (p. 192).

Almost opposite this quarry the flags exposed in the railway yielded *Trinucleus fimbriatus,* Murch., identified by Mr. E. T. Newton. [750 yards south of Ffairfâch Station, Carm. 41 NE.W λ 1, T.C.C. 354–356].

The most southerly exposure of the flags in the Cennen is in the bed of the river 200 yards south of Talhardd Farm, where black limestone dipping S. 10° E. at about 40° is to be seen.

West of the Cennen, in a depression between Pen-coed Farm and Talhardd Farm, thin-bedded dark limestones have been quarried 400 yards south-west of the former. At the end of a hedge sixty yards south of this quarry a small exposure of flags 350 yards N.E. of Cwrt-y-gorphwys yielded *Asaphus tyrannus,* Murch., *Calymene cambrensis,* Salt., *Orthis testudinaria,* Dalm., and *O. vespertilio,* J. de C. Sow. [Cwrt-y-gorphwys, Carm. 41 NE.E λ 3, T.C.C. 357–367].

T. C. C.

To the west, the series of sandy flags, etc., which occur above the Ffairfâch Grit dies out and its place is taken by typical calcareous flags and limestones.

At the head of the dingle, already mentioned (p. 17), as above the bridge at Golden grove, is the Ffairfâch Grit, and between this grit and the Silurian rocks the ground is occupied by flags and limestones of Llandilo age, which dip at 40°. These beds are thrown northwards by the fault which runs parallel to the dingle (p. 17), and may be traced westwards under and to the south of Golden Grove House as far as the Keeper's Lodge at Llanfihangel Aberbythych. The best exposure is in a quarry 100 yards east-south-east of the Keeper's Lodge, where a good series of flags and limestones may be seen dipping at 65° in directions varying from S. 10° W.

to S. 10° E. This locality is referred to by Phillips* as 'Golden Grove near the Keeper's Lodge,' from which he records several fossils. The following are preserved in the Museum of Practical Geology:—*Asaphus tyrannus*, Murch. (figured *Mem. Geol. Surv.*, dec. 2, pl. 5, figs. 5 and 9), *Rafinesquina corrugatella*, Dav. sp., *R. llandeiloensis*, Dav. sp. [10388 and P.S. 92–94].

To the immediate west the flags are faulted out for some distance, the Silurian being in contact with lower beds (p. 187). They reappear to the east of Carbury Mount in the higher part of the stream which marks the eastern end of the hill. This elliptical mound forms a striking feature, even when viewed from a distance; for being almost always of a bright-green colour, as is so often the case with Llandilo Flag country, it forms a great contrast to the more deeply coloured Silurian slopes of Berach and Lan which lie to the south. The hill owes its form to the faults which encompass it on all sides, and it may be regarded as one of many faulted lenticles.

Westwards, flags and limestones may be seen under the bridge where the road from Carbury Mount to Llanfihangel crosses the stream, and also at several points in the stream-bed to the south-west of the road. On Carbury Mount flags are exposed in a small quarry near the summit on the southern flank of the hill. They show an inversion or reversed dip of 50° N. instead of 50° S., as on the other side of the hill. This reversed dip is evidently local and unimportant, but its cause, unless it be due to hill-creep, is more or less obscure.

The limestones and flags are well exposed in the quarry near Pant-Glas (p. 18) at the western end of the hill, in the roadway leading to the farm, and in a small quarry 90 yards to the west of the house. In the large quarry the beds are disturbed although almost horizontal, but the dip gradually steepens southwards towards the smaller quarry, where it has a value of S. 15° E. at 60°. These flags yield abundant Llandilo trilobites.

H. H. T.

In Sheet 212, on the northern side of the River Towy, the Llandilo Flags and Limestones are typically developed and occupy the area of the town of Llandilo, where they are abundantly fossiliferous and have been extensively quarried. Westward they form the greater part of Dynevor Park, and occur between the alluvium of the Towy and the Redhill Beds, the northern boundary being a fault (p. 186).

T. C. C.

To the west of Dynevor Park they are faulted on the south against a broad strip of *Didymograptus bifidus* Shales and against Bala rocks on the north and west. They reappear to the south of Llangathen church and are well exposed on the hill between Cilsân Bridge and the village. A large quarry in limestone on the western side of the road, 100 yards west of Berllan-dywyll Farm is probably the locality referred to by Phillips* as 'Aberglasney.'

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* *Mem. Geol. Surv.*, vol. ii, pt. i, 1848, p. 325.

Three good limestone bands may be detected in the Llandilo Flags to the south of Llangathen village. They are abundantly fossiliferous and have been quarried along their respective outcrops. To the west the Llandilo Flags form the slopes of Berllan-dywyll Wood and enter Sheet 230 a little to the south of the camp on Grongar Hill, where they occupy the steep slope between it and the Towy alluvium. They are faulted against Redhill Beds on their northern and western sides, the fault gradually cutting across them in a south-westerly direction. With a strike of W. 30° S. and a dip towards the north they pass from Grongar Hill south-westwards to the south of Cwm-agal and Sarn-agal Farms, where they run below the alluvium of the River Towy. Near this point a vertical limestone-band, with *Asaphus tyrannus*, Murch. and *Ogygia buchi*, Brongn., occurs on the south of the road leading from Allt-y-gaer Farm to Dryslwyn, close to the alluvium. This limestone is quite near to the fault which separates the Llandilo rocks from the Redhill Beds, and is much disturbed, many of the beds being brecciated or contorted. To the west, the Llandilo Flags and Limestones reappear as a narrow faulted strip on the extreme south of Dryslwyn Castle Hill (Fig. 4). They occur to the north of the pump in a gorse-covered area, and have been quarried on the level of the alluvium ; they dip in a direction varying from S. 20° W. to S. 40° W., at angles changing from 40° to 90°. The limestones are abundantly fossiliferous and have yielded *Asaphus peltastes* ? Salt. (L), *Ogygia* ? (L.), *Trinucleus concentricus*, Eaton. var. *favus*, Salt. (L.). [Dryslwyn Castle, south side, Carm. 40 NE.E λ 4, J. P. 3984–3989].

On the north they are faulted against Bala Limestone (p. 32), which dips generally in a northerly and westerly direction.

BALA SERIES.

Dicranograptus Shales.

The most easterly exposure of *Dicranograptus* Shales within the confines of Sheet 230 is on Dryslwyn Castle Hill (fig. 4), where both the soft shales and their calcaceous development in the form of shaly limestones occur. The black shales are to be seen at several points on the northern flank of the hill, but perhaps to the best advantage under the wall, and in the well, immediately opposite the end of the road to Milton Court. At this locality they

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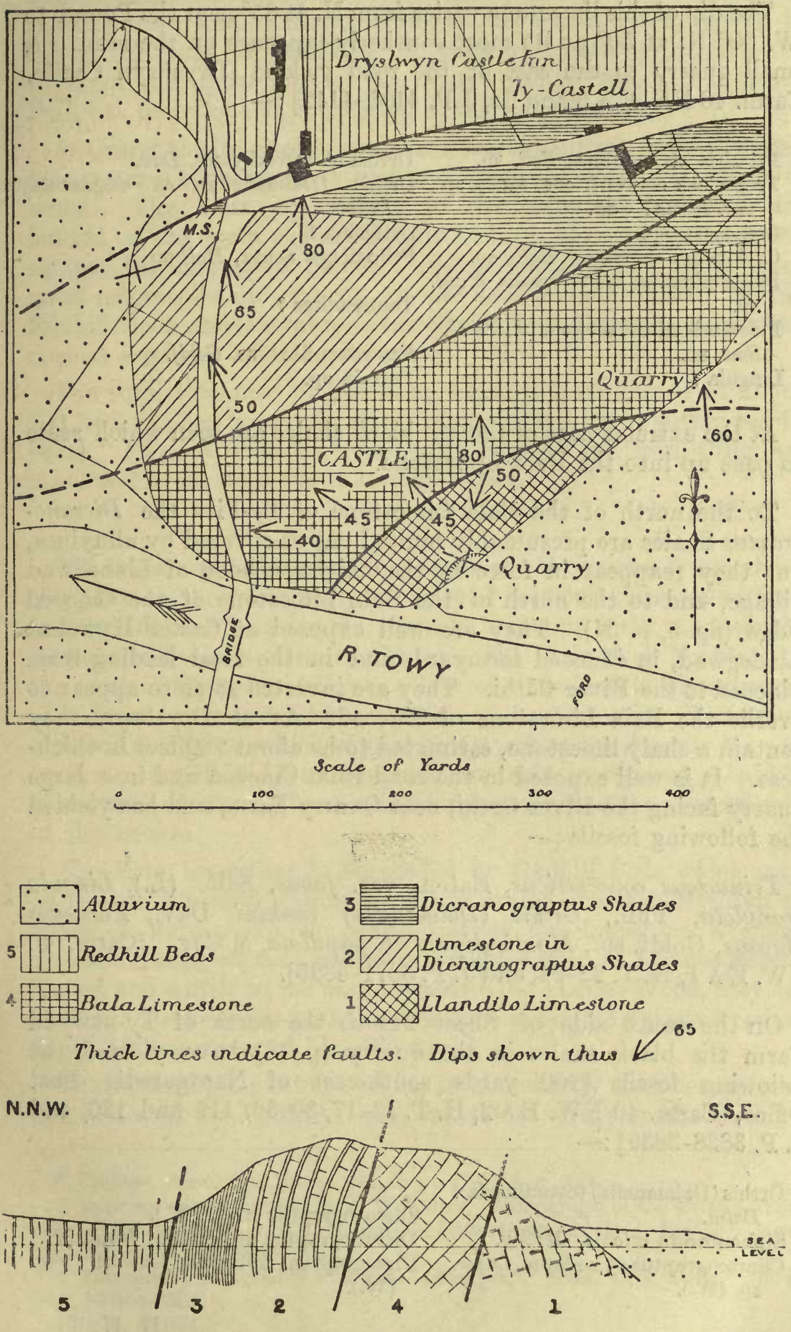
* *Mem. Geol. Surv.*, vol. ii. pt. i. 1848. p. 324.

Fig. 4.—*Map of, and Section across, Dryslwyn Castle Hill.*

By H. H. Thomas.



seem to pass downwards into a limestone which is well exposed in an old quarry near the Pound and along the road which forms the western boundary of the hill.

The dip of this limestone varies from N. at 85° near the Pound to W. 30° N. at 50° at its most southerly exposure on the road. A small quarry to the east of the road yielded [Dryslwyn Castle, Carm. 40 NE. E λ 5 and 5*a*, J.P. 4101–4142] :—

Primitia strangulata, *Salt.* sp.
Trinucleus concentricus, *Eaton* sp., var. favus ? *Salt.*
Orthoceras sp.
Cyclonema rupestris, *Baily* sp.
Plectambonites transversalis, *Wahl.* sp.
Plectambonites sericea, *J. de C. Sow.* sp.
Lingula ?

Orthis *cf.* sowerbyana, *Dav.*
Orthis (Dalmanella) *cf.* elegantula, *Dalm.*
Orthisina ?
Ptilodictya acuta, *Hall* sp.
Tentaculites ?
Favosites fibrosus, *Goldf.* sp.
Petraia sp.

At the extreme east of the hill black shales are seen which seem to pass up into the Bala Limestone.

To the north of the Bala Limestone of Ty-Pica the *Dicranograptus* Shales are presumably faulted out or covered by alluvium, but they reappear in force in the neighbourhood of Llanegwad village, and to the north of the Bala Limestone of the Cincoed ridge (fig. 5, p. 34). They are well exposed at Castell-Hywel at Llanegwad, in Cincoed farmyard, and in the road leading from Cincoed to the River Cothi. They are inverted so as to appear to overlie the Bala Limestone of Cincoed. As at Dryslwyn they contain a shaly limestone, estimated to be about 160 feet in thickness. It is well exposed in the road from Cincoed and in a large quarry facing the River Cothi, near Quarry Farm, and has yielded the following fossils :—

Trinucleus concentricus, Eaton, var. *favus*, Salt. (L.), *Lingula granulata*, Phil., *Orthis* (*Dalmanella*) *rankini*, Dav., *Favosites fibrosus*, Goldf. sp., *Monticulipora* cf. *papillata*, M'Coy. [Carm. 40 NW. E λ 1, H. T. 22–24, and J. P. 3871–3895].

On the south side of Sheet 211 to the north of Ty-newydd Farm the black shales in the quarry (p. 13) have yielded the following fossils [200 yards south-east of Nantgaredig Post Office, Carm. 40 NW. E λ 2, H. T. 13–17, 30–36, 119 and 120, and J. P. 3828–3839] :—

Orthis (Dalmanella) testudinaria ? *Dalm.*
Siphonotreta micula, *M'Coy.*
Climacograptus *cf.* cœlatus, *Lapw.* sp. (W.).

Climacograptus n.sp. (W.).
Dicranograptus nicholsoni ? *Hopk.* (W.)
Diplograptus foliaceus, *Murch.* var. (W.).

H. H. T.

Bala Limestone.

To the north of Sheet 230 the Bala Limestone is well developed at two localities, namely at Crûg, half a mile north-north-west of Llandilo town, and at Birdshill, two-thirds of a mile to the north of Cilsân Mill west of Llandilo. A mass of limestone forming the southern and upper part of the King's Lodge Wood in Dynevor Park has been doubtfully referred to the same horizon.

At Crûg * the limestone occurs as a faulted lenticle with its longer axis ranging approximately east and west, and about 600 yards in length. The beds dip steeply to the north at 66°, and are faulted on the north against Redhill Beds (p. 35), and on the south against *Dicranograptus* Shales. Neither of the two faults is of great magnitude and, except for the faulting-out of part of the Redhill Beds and *Dicranograptus* Shales, this district presents the normal sequence of Bala deposits.

The total thickness of limestone exposed is estimated at about 200 feet. It has been extensively quarried and burnt within recent years. *Phacops amphora*,† Salt., and *Illaenus* sp., from Crûg, are preserved in the museum at Jermyn Street.

T. C. C.

The limestone, as exposed in a series of old quarries lying about 300 yards to the west and north-west of Birdshill Farm, is vertical and strikes north-eastwards towards Dynevor Park, and south-westwards towards Glan-dwr Farm. The little river Myddyfi, to the west of Glan-dwr follows a line of considerable disturbance, and shows in its bed broken strata and fault-breccia. The effect of this disturbance, which runs almost north and south, has been to truncate the Bala Limestone, and to fault it against Llandilo Limestone, which may be seen in a large quarry‡ on the western side of the stream.

The Bala Limestone is succeeded by Redhill Beds which may be seen in the road leading from the bridge over the Myddyfi to Birdshill Farm. To the south-east of the limestone a slight depression suggests the presence of a narrow strip of *Dicranograptus* Shales, and a little to the east, towards King's Lodge Wood, they are visible. To the south-west the limestone is faulted against vertical flags and limestones of Llandilo age.

The Birdshill Limestone, which is abundantly fossiliferous, was first detected by Phillips § who mentioned many fossils from it.

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* Phillips, *Mem. Geol. Surv.*, vol. ii, pt. i, 1848, p. 324.

† Type specimen, figured by J. W. Salter, 'Monograph of the British Trilobites,' 1864–1883, pl. iv, figs. 16 and 17, *Palæontograph. Soc.* See also *Mem. Geol. Surv.*, dec. vii, 1853, p. 12.

‡ This quarry is probably Phillips's 'Glandwr.' *Mem. Geol. Surv.*, vol. ii, pt. i, 1848, p. 324.

§ *Ibid.*, p. 324.

The following are the forms preserved in the Museum of Practical Geology, collected partly during the original survey, and partly by Wyatt-Edgell [P.S. 52-79]:—

Cybele verrucosa. *Dalm.*
Orthoceras sp.
Leptæna rhomboidalis. *Wilck.* sp.
Plectambonites transversalis. *Wahl.* sp.
Orthis (Platystrophia) biforata. *Schloth.* sp.
Orthis calligramma. *Dalm.*
Orthis (Dinorthis) flabellulum. *J. de C. Sow.*
Orthis (Hebertella) vespertilio. *J. de C. Sow.*
Strophomena deltoidea? *Conrad*
Strophomena grandis, *J. de C. Sow.* sp.
Favosites fibrosus, *Goldf.* sp.

The following are entered in the Museum Register:—

* Cheirurus bimucronatus, *Murch.* sp.
* Illænus bowmanni, *Salt.*
‡ Ambonychia triton, *Salt.* sp.
§ Pleurotomaria qualteriata, *Schloth.* sp.
† Orthis (Plæsiomys) porcata. *M'Coy.*

Recent collection has resulted in the following list of fossils [Old Quarry 200 yards N.W. of Birdshill Farm, Carm. 33 SW.Eλ 2, J.P. 4007-4100]:—

Amypx ?
Calymene blumenbachi, *Brongn.*, var. drummuckensis, *Reed.*
Cybele verrucosa. *Dalm.*
Illænus bowmanni ? *Salt.*
Illænus murchisoni, *Salt.*
Phacops (Acaste) apiculatus, *Salt.*
Leptæna rhomboidalis, *Wilck.* sp.
Plectambonites transversalis. *Wahl.* sp.
Orbiculoidea perrugata, *M'Coy* sp.
Orthis (Platystrophia) biforata, *Schloth.* sp.
Orthis (Platystrophia) biforata, *Schloth.* sp. var. terebratularis, *Schloth.*
Orthis (Plæsiomys) porcata, *M'Coy*
Orthis (Hebertella) vespertilio, *J. de C. Sow.*
Strophomena ungula, *M'Coy.*
Ptilodictya, *cf.* acuta, *Hall*
Ptilodictya dichotoma ? *Portl.*
Ptilodictya recta ? *Hall*
Ptilodictya n.sp.
Favosites fibrosus, *Goldf.*
Cyathophyllum ?

From Birdshill (p. 31) to Dryslwyn a fault cuts out the Bala Limestone and *Dicranograptus* Shales, leaving the Llandilo Flags in contact with Redhill Beds (p. 35). At Dryslwyn, however, the Bala Limestone re-appears and forms the greater part of the centre and south side of the Castle-Hill (Fig. 4). The limestone is inverted, having an apparent dip in northerly and westerly directions. It is faulted on the south side against Llandilo Limestone and on the north against *Dicranograptus* Limestone; at the east end of the hill, however, there seems to be some black *Dicranograptus* Shales into which it passes normally.

The limestone forms the conspicuous crags on which stand the ruins of the castle, and from the most westerly of these crags, just below the castle-wall, the following fossils have been obtained: *Beyrichia* sp., *Cybele verrucosa*, Dalm., *Plectambonites sericea*, *J. de C. Sow.* sp., *Orthis* (*Dalmanella*) *elegantula* ? Dalm., *Rafinesquina* sp., *Retepora* sp. and *Cyathophyllum* ? [West side of Dryslwyn Castle, Carm. 19 NE.E λ 6, J. P. 4143-4156].

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* Wyatt-Edgell collection.
† Figured *Mem. Geol. Surv.*, vol. ii, pt. i. pl. xxvii. fig. 3, and fig. 4 ?
‡ *Ibid.*, pl. xxiii, fig. 5.
§ *Ibid.*, pl. xiv, fig. 7.

To the west of Dryslwyn the Bala Limestone passes under the alluvium, but appears again at Ty-pica to the north-east of Llanarthney. It forms a low elliptical hill, the long axis of which runs parallel to the strike of the beds, that is almost east and west. The limestone, together with some sandy shales, is well exposed in a small quarry on the southern flank of the hill near its western extremity; it is somewhat sheared, the shear-planes making an angle of 60° with the bedding which dips N. 30° W. at 70°. It has yielded the following fossils:—*Cybele verrucosa*, Dalm., (L.), *Illænus murchisoni*, Salt. sp. (L.), *Plectambonites sericea*, J. de C. Sow. sp., *Lingula ovata* ? M'Coy and *Orthis hirnantensis* ? M'Coy [Quarry at Ty-pica, Carm. 40 NE.E λ 3, J. P. 4157–4170].

At Ty-pica, as at Dryslwyn, the limestone is inverted, for there is distinct evidence that a certain thickness of Redhill Beds occurs on the south side of Ty-pica Hill. Passing under the alluvium, the limestone is in all probability soon cut off by a fault, only to reappear further to the north, to the west of Llanegwad. Emerging from a fault, which has *Dicranograptus* Shales on its eastern side, it ranges from Pen-y-Knap, above Llŵch-gwyn to Allt-y-Cincoed (Fig. 5), forming a prominent ridge. Westward it passes under the higher alluvium of the River Cothi. The limestone as before is inverted, having Redhill Beds on the south and *Dicranograptus* Shales on the north. It is best exposed in an old quarry above the road leading to Llŵch-gwyn, near the cottage called Pen-y-goilan, and at the western end of Allt-y-Cincoed. In the quarry it is thin bedded and sandy, and is quite near the summit of the limestone series. It has yielded the following fossils [Old Quarry near Pen-y-goilan, Carm. 40 NE.W λ 3, J.P. 3576–3651]:—

Calymene senaria, (*Conr.*) *Salt.*
Cybele verrucosa, *Dalm.*
Cyclonema ?
Atrypa imbricata, *J. de C. Sow.* sp.
Leptæna rhomboidalis, *Wilck.* sp.
Orthis (Heterorthis) alternata ? *J. de C. Sow.*
Orthis (Platystrophia) biforata, *Schloth.* sp.
Orthis (Dinorthis) flabellulum, *J. de C. Sow.*
Orthis (Plæsiomys) porcata, *M'Coy*
Orthis (Dalmanella) rankini ? *Dav.*
Orthis *cf.* rustica, *J. de C. Sow.*
Orthis sp.
Plectambonites quinquecostata, *M'Coy* sp.
Plectambonites sericea, *J. de C. Sow.* sp.
Ptilodictya acuta, *Hall*
Cornulites sp.
Aulacophyllum ?
Cyathophyllum sp.
Favosites fibrosus, *Goldf.* sp.
Heliolites interstinctus, *Linn.* sp.
Monticulipora sp.
Petraia rugosa, *Phil.*
Nidulites sp.

This quarry is referred to by Phillips* under the title of 'Llŵch-gwyn near Pont-ar-Cothi,' and he records several well-known Bala species.

H. H. T.

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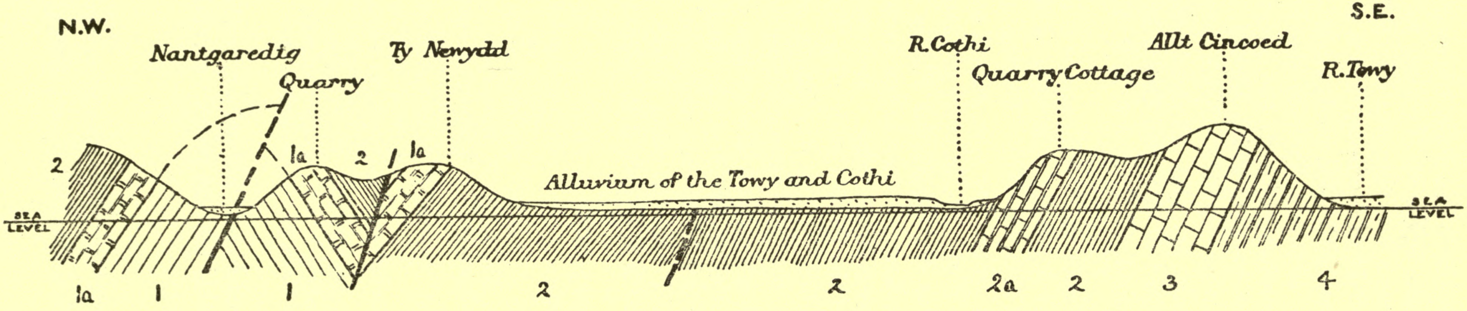
* *Mem. Geol. Surv.*, vol. ii, pt. i, 1848, p. 324.

FIG. 5.—*Section across the Ty-newydd and Cincoed ridges.*

BY H. H. THOMAS.



Horizontal scale, 6 inches to 1 mile.

4. Redhill Beds.
3. Bala Limestone.
2. *Dicranograptus* Shales.
2a. Limestone in *Dicranograptus* Shales.
1a. Llandilo Flags and Limestone.
1. *Didymograptus murchisoni* Shales.

Redhill and Slade Beds.

In the neighbourhood of Birdshill (Sheet 212) the passage from the Bala Limestone into Redhill Beds is well seen in the road leading from the bridge over the River Myddyfi to Birdshill Farm, and it may also be observed on the southern side of Allt-y-Cincoed (Sheet 230). In Sheet 212 the Redhill Beds occupy a disturbed belt averaging about two-thirds of a mile in width. They range from Crûg at Llandilo, to the north of Dynevor Park and Birdshill, through Llangathen village, to the north of Grongar Hill into Sheet 230. Generally speaking, this belt is faulted on both sides, having Llandilo Flags on the south and *Dicranograptus* Shales on the north.

The Redhill Beds are well exposed all along the line, and their limits can be traced with accuracy. An exposure in a brook 400 yards south-west of Glan-lash Farm near Broadoak has yielded the following fossils [Carm. 33 SW.W λ 1, J.P. 3931–3961]:—

Orthoceras sp.
Leptæna rhomboidalis, *Wilck.* sp.
Plectambonites sericea ? *J. de C. Sow.* sp.
Orthis actoniæ, *J. de C. Sow.*
Rafinesquina expansa? *J. de C. Sow.* sp.
Orthis *cf.* hirnantensis, *M'Coy*
Orthis turgida ? *M'Coy*
Favosites fibrosus, *Goldf.* sp.
Heliolites interstinctus ? *Linn.* sp.
Petraia sp.

The forms *Orthoceras* cf. *vagans*, Salt., *Diplograptus* cf. *rugosus*, Emmons, (W.), and *Cornulites* ? were obtained from a quarry in Cwm-du-morle Wood, 280 yards north-north-east of Glan-lash Farm [Carm. 33 SW.W λ 2, J.P. 3962–3980].

The belt of Redhill Beds mentioned above enters the map to the west of Grongar Hill, faulted on its southern side and forming the lower ground between Grongar Hill and Dryslwyn Castle. The mudstones may be examined to advantage in a cartroad to the north of Cwm-agal Farm, in a quarry 300 yards N.E. of Dryslwyn-uchaf Farm, in a small quarry in the field to the west of the farm, and in the road from Cwm-agal to Dryslwyn Castle.

To the west of the River Dulais they occupy the ground to the north of Ty-pica and may be seen at Deri-moelion, Glan-Towy, and Cefn-hernin Farms. West of Glan-Towy Farm a wide valley hides their faulted junction with the *Dicranograptus* Shales which make their appearance to the north of the map near the Halfway-House Inn on the Carmarthen road and continue westward to Llanegwad (p. 30).

The Redhill Beds to the north of Cwm-agal are much disturbed and not very fossiliferous. They have a general dip in a northerly direction of from 35° to 45°. In the neighbourhood of Dryslwyn-uchaf Farm they are more fossiliferous and the road-section to the east of the farm has furnished *Orthoceras* sp., *Plectambonites* sp., *Ctenodonta* cf. *obliqua*, Portl. sp., and *Petraia* sp. [Road east of Dryslwyn-uchaf Farm, Carm. 41 NW.W λ 2, J.P. 3765–3769].

To the north of Dryslwyn Castle yellow-weathering shales and calcareous mudstones are exposed on the eastern side of the road leading from Dryslwyn to Felindre, at a point 200 yards north of Dryslwyn-fâch Cottage. The beds seem to approximate to the horizon of the Bala Limestone and might be regarded at the lowest part of the Redhill Group. They yielded *Encrinurus* sp., (L.), *Phacops* (*Acaste*) *apiculatus*, Salt. (L.), *Plectambonites sericea*, J. de C. Sow. sp., *Obolella* ?, *Orthis calligramma*, Dalm. [Dryslwyn-fâch, Carm. 40 NE.E λ 2, J.P. 4189–4211].

The shales of Glan-Towy and to the north of that farm yield few fossils, but lithologically they belong to the Redhill Beds. They are faulted off from the Bala Limestone of Ty-pica which has apparently Redhill Beds on its southern side. On the solid edition of the map the geology has had to be filled in under an area west of Llanarthney, which is not only overspread by glacial gravel, but is surrounded by river-terrace and alluvium. In such a disturbed area as the Towy Valley, it is possible only to conjecture what rocks may lie hidden, but from a careful consideration of those structures, which are to be seen and inferred on the north and south sides of the valley, it seems probable that rocks chiefly of Bala age are represented. The area has, therefore, been coloured as Redhill Beds, but it is quite possible that Bala Limestone and *Dicranograptus* Shales also occur.

H. H. T.

CHAPTER IV.

SILURIAN ROCKS.

By T. C. Cantrill and H. H. Thomas.

Introduction.

Murchison, in his *Silurian System*, shows ‘ Upper Silurian Rocks ’ (Ludlow and Wenlock), both on his map and sections, as extending south-westwards past Llangadock and Llandilo as far as Haverfordwest in Pembrokeshire. In the sequel, however, it will be seen that the Silurian rocks are overstepped by the Old Red Sandstone south-west of Llanarthney, and that beyond this place Murchison's supposed Ludlow and Wenlock are certain unfossiliferous green marls and sandstones which set in at the base of the Old Red Sandstone. He observed that the Ludlow and Wenlock are not lithologically distinguishable, and that workable limestone-bands are not found west of the River Sawdde near Llangadock.

In the first edition of the Geological Survey Map and Sections, the Upper Llandovery rocks were not indicated, but they were added by Aveline in 1855–6.

W. S. Symonds,* following Murchison, speaks of the ‘ Upper Silurian ’ as thinning out to a mere band near Llandilo and Carmarthen, but also mistook the green basal beds of the Old Red Sandstone south of Carmarthen for Ludlow rocks.

John Phillips† describes the grouping of the lithological types of the ‘ Lower and Upper Silurian Rocks ’ near Llandilo, and used the term Myddelton Series‡ for the combined Wenlock and Ludlow Beds. He gives numerous lists of fossils from various sections, and these we have embodied in the following pages so far as it has been possible to confirm the identifications.

In the maps and memoirs embodying the results of the re-survey now in progress the term Ordovician has been adopted in place of Lower Silurian, and the term Silurian is restricted to the ‘ Upper Silurian ’ of old authors.

M‘Coy obtained from the Ludlow-Wenlock Beds of Parklane, Llandilo, his figured specimens of *Modiolopsis gradata*, Salt. sp. and *Pterinea pleuroptera*, Conrad ; and from the Tilestones of Storm

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* ‘ Records of the Rocks,’ 1872, p. 191.

† ‘ The Malvern Hills compared with the Palæozoic Districts of Abberley, etc.,’ *Mem. Geol. Surv.*, vol. ii, pt. i, 1848, p. 220 *et sep.*

‡ *Ibid.* p. 225.

Hill* the types of *Anodontopsis quadrata*, *Dolabra elliptica*, *D. obtusa*, *Pterinea megaloba*, and *Murchisonia torquata*; † the specimens are preserved in the Sedgwick Memorial Museum, Cambridge. From 'Golden Grove' (p. 49) Phillips obtained *Mytilus mytilimeris*, Conrad sp. (Figd. Mem. Geol. Surv. vol ii, pt. i, Pl. 20, fig. 7); from 'Swansea Road' (p. 49) *Mytilus exasperatus*, Phil. (Figd. Mem. Geol. Surv., vol. ii, pt. i, Pl. 20, fig. 12) and from 'West of Wern, Llandeilo' *Orthonota rigida*, J. de C. Sow sp., (Figd. Mem. Geol. Surv., vol. ii, pt. i, Pl. 19, figs. 1 and 2). For a complete list of Silurian fossils from Sheet 230, see pp. 229, 230).

The Silurian rocks, where best developed in the neighbourhood lying east of Llandilo, present the following subdivisions in descending order:—

		Ft.
Ludlow and Wenlock.	*Tilestones.*—Yellow, highly micaceous sandstones and pebbly grits, very fossiliferous - - - - about	150
	Trichrûg Beds.—Red grits, sandstones, and sandy marls, mostly pebbly, passing down into yellow grits - -	600
	Grammysia Bed.—Dark purple-grey flaggy sandstones characterised by *Grammysia* - - - - - - -	180
	Greenish-buff mudstones with thin harder seams, about 600 feet *Lletty Grit.*—Yellow sandstone 200 ft. Greenish-grey mudstones at least 1,200 feet	2,000

To the south of Golden Grove the sequence of beds in descending order with their approximate thicknesses is as follows:—

Tilestones - - - - - - -	150 feet	and thinning westward.
Trichrûg Beds (white grits) - -	90 ,,	,, ..
Mudstones and sandstones - - -	750 ,,	
Lletty grit - - - - - -	180 ,,	
Mudstones sandstones and limestones	1,200 ,,	Base not seen.

From Golden Grove westwards these beds strike about 10° to 20 south of west and dip at about 80° to 100° in a southerly direction. Their outcrop is about half a mile in width as far as the main road to Dryslwyn, but there begins to narrow and the strike becomes almost due west. It continues to narrow westwards, and to the immediate south of Dryslwyn the strike turns a little north of west, while the beds sweep round the wooded slopes to the north of Nelson's Tower. At Allt-Pistyll-Dewi the outcrop again turns southward and strikes W. 30° to 40° S. towards Middleton Hall. Here it has narrowed to 300 yards and in a little over a mile the whole of the Silurian beds have passed beneath the Old Red Sandstone.

From the main road to Dryslwyn, mentioned above, to the extreme west only the lower set of mudstones and sandstones is present. Along the wooded slopes to the west of Llanarthney it has a very gritty character towards its upper limit.

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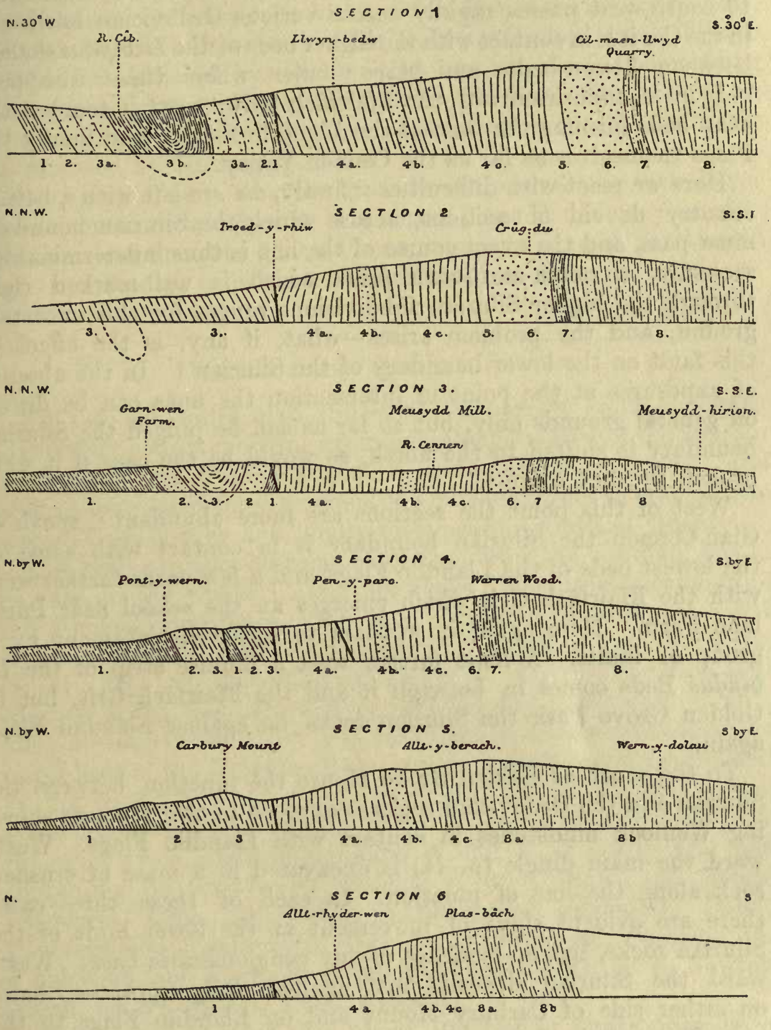
* M'Coy, *Ann. Mag. Nat. Hist.*, ser. 2, vol. vii, 1851, p. 45; and vol. x, 1852, p. 189.

† *Cyrtostropha torquata*; J. Donald, *Quart. Journ. Geol. Soc.*, vol. lviii, 1902, p. 313.

Fig. 6.—*Comparative Sections from the Old Red Sandstone across the Silurian to the Ordovician Rocks.*

BY T. C. CANTRILL AND H. H. THOMAS.



8. Old Red Sandstone { b. Red Marls. / a. Basal Green Beds.
7. Tilestones.
6. Trichrûg Beds.
5. *Grammysia* Bed.

4c and 4a. Ludlow-Wenlock.
4b. Lletty Grit.
3. Llandilo Flags. { b. Flags. / a. Basement Beds.
2 Ffairfâch Grit.

1. *Didymograptus-bifidus* Beds.

The Silurian-Ordovician Junction.

We have seen (pp. 8, 9) when dealing with the general structure of the Llandilo district, that the sequence on the north of the Llandilo anticline is more complete than that on the south. Moreover, the Silurian lower boundary in its course from north-east to south-west passes rapidly across various Ordovician horizons; in the Cîb it is in contact with the higher beds of the *D. bifidus* shales; between Llwyn-bedw and Maes-y-fallen where these disappear it is in juxtaposition with the Ffairfâch Grit; next it touches the ashy beds forming the base of the Llandilo Flags; and finally the Flags themselves as far as the Cennen Valley.

Here we meet with difficulties; firstly, we are left with a belt of country devoid of sections, across which the Silurian boundary must pass, and the exact course of the line is thus indeterminable; secondly, a north-and-south fault which is well-marked right through the higher Silurian subdivisions ranges for this uncertain ground, and the problem arises—what, if any, is the effect of this fault on the lower boundary of the Silurian? In the absence of exposures at the point of intersection the lines can be drawn on general grounds only, but so far as can be judged the Silurian boundary is shifted to the north, as would be the case if it were broken by such a fault.

West of this point the sections are more abundant: south of Glan-Cennen the Silurian boundary is in contact with some of the lowest beds of the Llandilo Flags, and a few yards farther west with the Ffairfâch Grit which emerges at the school near Parklane Farm. Here again it appears to suffer displacement by a group of faults. A little farther west a minute strip of the *D. bifidus* Beds comes in between it and the Ffairfâch Grit, but in Golden Grove Park the Silurian rocks lie against Llandilo Flags again.

To the south of Golden Grove House the junction between the Silurian and the Ordovician rocks is exposed in two streams showing Wenlock mudstones in contact with Llandilo Flags. Westward the main dingle (p. 44) is excavated in a mass of crushed rock along the line of junction. In each of these three cases there are evident signs of movement at the lower limit of the Silurian rocks, but no evidence of any conglomeratic base. Westward the Silurian deposits rest against *Didymograptus* Shales on either side of Carbury Mount and on Llandilo Flags to the immediate south of that hill.

From these observations it follows that the Silurian-Ordovician junction is either a great unconformity or a fault of large throw, or a combination of unconformity and fault.

That an unconformity exists at the base of the Upper Llandovery in Shropshire is well-known, and might be sufficient to account for the transgression described above, but there is convincing evidence that there has been much subsequent movement along the junction of the Silurian and Ordovician rocks. Although the Silurian lies against rocks of widely different type, both hard and soft, yet nowhere is there a conglomerate or any rock which can be regarded as a beach-deposit; this is true at Llwyn-bedw, and also at Troed-y-rhiw, where the actual junction may be examined, and again at Parklane Farm, where we see the Silurian mudstones of ordinary type within a few feet of the Ffairfâch Grit. The conclusion follows that some beds are faulted out. This is further strengthened by the fact that crushing and slickensiding are especially conspicuous along the junction. On the whole it seems most likely that there is a considerable unconformity accentuated by faulting (p. 187).

The question as to whether the fault is a normal one with downthrow south, or whether it is a thrust-plane is not capable of a definite answer; on general considerations it may be inferred that the Silurian beds have been thrust over from the south.

T.C.C. and H.H.T.

Wenlock and Ludlow Series.

On the old series map (Sheet 41) a narrow band of Upper Llandovery beds is shown as extending along the base of the Silurian south-westwards from Llangadock as far as Maes-y-fallen; and after an interval of three-quarters of a mile as coming in again a little east of Troed-y-rhiw and finally disappearing south of Maerdy.

The fossil evidence to some extent confirms the old map, but in no case do the Upper Llandovery rocks differ lithologically from the Wenlock mudstones. We have succeeded in obtaining a few Upper Llandovery fossils in the river Cîb south of Tir-y-lan Farm (Sheet 212): on proceeding up stream we find the Ffairfâch Grit exposed in the bed of the river and dipping north-west at 25°; after an interval of about 100 yards sandy micaceous shales (the upper beds of the *D. bifidus* Beds) appear, undulating in dip towards W. 25° to 30° N.; some sixty yards still farther up stream (and about 1,000 yards above Cwm-Cîb Farm) we get Silurian rocks, consisting of green mudstones dipping W. 35° N. at nearly 90°; and containing *Stricklandinia ? undata*, J. de C. Sow. sp., *Atrypa reticularis*, Linn. sp., *Orthis* (*Dalmanella*) *elegantula*, Dalm., *Plectambonites transversalis*, Wahl. sp., *Petraia* sp., *Favosites* sp., a polyzoan, and a crinoid stem, identified by Mr. E. T. Newton. [Carm. 34 SW.W λ 1, T.C.C. 434–441].

These fossils suggest that about 100 feet of strata may be of Upper Llandovery age.

At 100 yards higher up stream (at about 1,100 yards above Cwm-Cîb Farm) olive-green micaceous mudstones dipping E.S.E. and S. 35° E. at 80° or 90° yielded *Monograptus* sp. [Carm. 34 SW.W λ 2, T.C.C. 433], identified by Miss E. M. R. Wood as intermediate between *M. flemingi*, Salt., and *M. colonus*, Barr., and referred by Dr. Lapworth and Miss G. L. Elles to a horizon in the uppermost Wenlock or lowest Ludlow. In the Builth district* the Wenlock beds reach a thickness of 1640 feet, the higher zone alone (that of *Cyrtograptus lundgreni*) being 440 feet. In the Cîb section we have only 200 feet of beds, within which there is no evidence of any hiatus. We conclude, therefore, that the Upper Llandovery, Tarannon, and most of the Wenlock are overlapped, and that the 'Upper Llandovery' of this district is only a litoral facies of some high horizon of the Wenlock. Such an overlap has been noted near Builth, where the uppermost zone of the Wenlock rapidly overlaps all the lower ones, and finally rests directly upon pre-Silurian deposits.

Again, at Troed-y-rhiw, south-south-east of Ffairfâch, the Silurian rock in contact with the Ordovician consists of olive-green mudstones with one or two harder bands (up to five inches) exposed in the west bank of the lane, one of which about 12 feet from the junction with the Llandilo Flags (about 100 yards south-east of the farm) yielded *Stricklandinia* ? *undata* ? J. de C. Sow. sp., and *Atrypa reticularis*, Linn. sp., as named by Mr. E. T. Newton [Carm. 41. NE.E λ 13, T.C.C. 350, 351]. It appears that the fossils present an Upper Llandovery facies, but in view of the peculiar faunal assemblage obtained at Rumney, where Prof. Sollas† was led to extend the range of *Pentamerus* well up into the Wenlock, it seems undesirable to remove these beds from that series.

In the mass of mudstones following the beds above described it has not proved possible to distinguish the Tarannon Shales, nor is there any obvious lithological difference between the Wenlock and the Ludlow subdivisions. The name Myddelton Series used by J. Phillips‡ for the whole group was therefore suitable, but Middleton Series having since been adopted for one of the Ordovician subdivisions of Shropshire, it has been thought better to dispense with it.

In a section afforded by a lane running north-east from Llwyn-bedw there are seen brownish-yellow and green mudstones dipping S. 20°–40° E. at 70° and more or less disturbed. A better section on a path and in the stream 150 yards west of Llwyn-bedw shows brownish-yellow and green mudstones and shales yielding *Leptæna rhomboidalis*, Wilck. sp., *Plectambonites transversalis* ? Wahl. sp., *Phacops* (*Dalmania*) *caudatus*, Brünn. sp., *Cyphaspis megalops* ? M'Coy sp., *Beyrichia* sp., and crinoid remains, identified by Mr. E. T. Newton [Carm. 42 NW.W λ 4, T.C.C. 372–377]. The section is more or less continuous down to the Silurian boundary (p. 15); some 20 yards south of a ruined building (200 yards west of Llwyn-bedw) and only 30 from the junction the beds yielded *Calymene blumenbachi*, Brongn., identified by Mr. E. T. Newton. [Carm. 42 NW.W λ 2, T.C.C. 370, 371].

South of Maes-y-fallen a cart-road obliquely ascending the Silurian escarpment shows green shales in which we were unable to detect any fossils.

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* G. L. Elles, *Quart. Journ. Geol. Soc.*, vol. lvi, 1900, p. 370.

† *Quart. Journ. Geol. Soc.*, vol. xxxv, 1879, p. 475.

‡ *Mem. Geol. Surv.*, vol. ii, pt. i, 1848, p. 225.

Two brooks east of the Llandilo-Trapp road at Maes-Evan Farm and south of the Reservoir yield good sections of the mudstones; the following fossils were obtained in the eastern brook 350 yards south-east of the reservoir:—*Spirifer* (*Cyrtia*) *exporrectus*, Wahl. sp., *Atrypa reticularis*, Linn. sp., *Leptæna rhomboidalis*, Wilck. sp., *Strophomena* sp. and *Orthis* sp., identified by Mr. E. T. Newton. [Reservoir, 1 mile E. of Ffairfâch, Carm. 41 NE. E λ 4, T.C.C. 315–321].

A small quarry 100 yards east of Ty-newydd shows green sandy shales and mudstones; some decalcified bands yielded abundant fossils, of which the following is a list identified by Mr. E. T. Newton [Carm. 41 NE. E λ 1, T.C.C. 278–296]:—

Phacops (Dalmania) caudatus, *Brünn.* sp.
Calymene blumenbachi, *Brongn.*
Encrinurus punctatus, *Brünn.* sp.
Cyclonema cf. subsulcata, *Portl.* sp.
Mytilus mytilimeris ? *Conrad* sp.
Pterinea fimbriata, *M'Coy*
Pterinea mira, *Barr.*
Spirifer (Cyrtia) exporrectus, *Wahl.* sp.
Atrypa reticularis, *Linn.* sp.
Leptæna rhomboidalis, *Wilck.* sp.
Strophonella euglypha ? *His.* sp.
Pentamerus sp.
Orthis elegantula, *Dalm.*
Monticulipora ?
Favosites sp.

At Troed-y-rhiw a lane descending the escarpment crosses the possible Upper Llandovery beds (p. 42), above which, and 40 feet south of their junction with the Llandilo Flags, *Phacops caudatus* was found, and at a quarry about 100 yards higher up the lane (and 200 yards south-south-east of the farm) the beds yielded *Phacops* (*Dalmania*) *caudatus*, Brünn. sp., *Atrypa reticularis*, Linn. sp., *Leptæna rhomboidalis*, Wilck. sp., *Spirifer* (*Cyrtia*) *exporrectus*, Wahl. sp., and *Pentamerus oblongus* ? J. de C. Sow., identified by Mr. E. T. Newton. [Carm. 41 NE. E λ 3, T.C.C. 309–314].

There are one or two small exposures on the railway south of Talhardd, but a better one is to be seen at Parklane Farm, where bare mudstones apparently nearly vertical and striking W. 25° N. and W. 25° S. form the surface of the yard; they are traversed by several small north-and-south faults displacing a few inches. The brook west of Parklane Farm traverses the lowest visible Silurian beds consisting, as usual, of olive-green mudstones, but yielding no fossils; they are nearly vertical and dip about S. 15° E. Higher beds are laid bare in a small opening 70 yards west of Pwll-llaca and consist of brown and grey sandy mudstones with thin bands of sandstone; and there is a large old quarry named Clay Pit on the six-inch map (Carm. 41 N.E.) in Golden Grove Park, some 300 yards farther west, in which the green and buff mudstones yield ordinary Wenlock fossils. This is possibly the locality mentioned by J. Phillips* under the name 'Golden Grove, east of the House.'

All the above sections occur in the lower horizons of the Wenlock-Ludlow group and below the Lletty Grit.

T. C. C.

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* *Mem. Geol. Surv.*, vol. ii, 1848, pt. i, p. 325.

These mudstones and sandstones, occupying a position to the north of and below the Lletty Grit, are well exposed in each of three streams which flow northward from the high ground of Golden Grove Park. The most westerly stream, after flowing some distance parallel to the others, turns eastward and receives them as tributaries, the united stream turning again to the north and occupying the dingle above Golden Grove Bridge (p. 17).

Its easterly course marks the line of junction between the Silurian rocks and the Llandilo Flags to the north.

The easterly stream shows the following section 250 yards in length. At the point where this tributary stream flows into the east-and-west dingle the Ffairfâch Grit is exposed (p. 20) and is immediately succeeded to the south by Llandilo Flags which dip to the south at 40°. A few yards further the bed of the stream shows Silurian mudstones inverted so as to appear to dip north at about 70° to 80°. About 70 yards from the main stream the dingle is crossed by a small fault which forms the northern limit of a thin bed of dark blue-grey crystalline limestone. From this point southwards the beds dip normally to the south at 70° to 75°. The middle stream shows a section 400 yards in length; at its lower end Llandilo Flags are exposed for a few yards, and then, for 100 yards, bluish-green mudstones dipping south at 80°. The stream then crosses the east-and-west fault mentioned in the preceding section, which here again is followed by the same dark limestone. Southwards the section continues in a series of alternating mudstones and sandstones.

A little east of the head of the above-mentioned stream is an old quarry in green sandstones and mudstones dipping S. 12° E. at 80° to 90°. The beds are traversed by small overthrust faults which suggest movement from a southerly direction. The main stream during its easterly course follows the junction between the Silurian and Ordovician rocks. For the 250 yards thus exposed the crushing and shearing of the neighbouring beds leave no doubt of its being a faulted junction. At the eastern end of this dingle, as we have seen, is the Ffairfâch Grit followed to the west by a faulted mass of *Didymograptus* shales, and then Llandilo flags to the north and Silurian mudstones to the south. After 250 yards in a westerly direction the dingle turns south-westward and shows a more or less continuous section in Silurian rocks for about 500 yards. The beds are much disturbed, the strike and dip varying considerably.

An old quarry, on the eastern side of the stream and a little to the south of the point where it changes its direction, shows a mass of smashed mudstones. The shearing has been sufficiently intense to produce foliation and partial reconstruction.

A short distance to the west of this stream the Silurian rocks are displaced to the north by the Keeper's Lodge Fault (p. 180).

To the west of the fault the mudstones are well exposed in several streams which flow northward and unite at the foot of the steep slope 100 yards to the north-west of Llanfihangel vicarage.

A considerable number of fossils were collected by J. W. Salter and R. Gibbs from this locality in 1855, among which the following are preserved [P.S. 80–91]:—

Phacops (Dalmania) caudatus, *Brünn.* sp.
Plectambonites transversalis, *Dalm.* sp.
Orthis calligramma, *Dalm.*, var. davidsoni, *Lindst.*
Orthis cf. bouchardi, *Dav.*
Petraia elongata, *Phil.* sp.

Phillips, however, referred to this locality and mentioned fossils from it at an earlier date.*

Traced westward, these mudstones and sandstones form the steep slopes of Berach (Allt-y-berach) and Lan (Allt-y-Lan); they are well exposed at Berach Farm and in most of the streams which drain northwards from the Silurian ridge.

An almost continuous exposure occurs in the road to Dryslwyn from the Old Red Sandstone to the bottom of the hill at Ty-canol; at a point on the road east of Pant-mawr, 220 yards below the cottage Pen-cae'r-eithin, the beds are very fossiliferous. The following fossils in the Survey collection are probably from this road-section; they appear under the name of 'Pont Onawn,' probably an incorrect transliteration of Pant Mawr:—*Spirifer elevatus*, Dalm. sp., *S. plicatellus*, Linn. sp., var. *interlineatus*, J. de C. Sow., *Pterinea* sp. [P.S. 44–51, and 337].

Four hundred and fifty yards to the west of the main road just below the Old Red Sandstone is a road-section at Pen-y-rhiw. This is probably the locality mentioned by Phillips as 'Cnwc.'†

Westward the mudstones and sandstones occupy the slopes of Allt Fawr‡ to the south of Dryslwyn.

At a point on the Carmarthen road opposite Ty-newydd Farm, one mile from Llanarthney, the lowest visible Silurian strata consist of calcareous mudstones which pass into a dark crystalline limestone. The limestone is very fossiliferous and has yielded *Calymene blumenbachi*, Brongn., *Orthis* (*Platystrophia*) *biforata*, Schloth. sp., *O. calligramma*, Dalm., *Pentamerus* sp., identified by Mr. E. T. Newton. [Ty-newydd, Carm. 40 NE. E λ 1, H.T. 25–29].

The limestone may be traced westwards and is well seen in an old quarry 100 yards south-east of Pistyll-Dewi Farm. This quarry in 1855, during the original survey of the district, yielded to R. Gibbs [P.S. 251–292]:—

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* *Mem. Geol. Surv.*, vol. ii, pt. i, 1848, p. 325 [Golden Grove, near Keeper's Lodge.]

† *Ibid.* p. 324. Also Sheet 41 old series map.

‡ *Ibid.* p. 325. ['Rhiw-Goch' is the slope between Troed-y-rhiw-gôch and Pen-rhiw-gôch, part of Allt Fawr.]

Acidaspis sp.
Illænus sp.
Illænus barriensis, *Murch.*
Phacops (Dalmania) caudatus, *Brünn.* sp.
Proetus n. sp.
Proetus latifrons ? *M'Coy*
Orthoceras annulatum, *J. Sow.*
Platyceras haliotis, *J. de C. Sow.* sp.
Pterinea planulata, *Conrad*
Dictyonella capewelli, *Dav.* sp.
Orthis (Platystrophia) biforata, *Schloth.* sp.
Orthis protensa ? *J. de. C. Sow.*
Rhynchotreta cuneata, *Dalm.* sp.
Spirifer elevatus, *Dalm.*
Strophomena pecten, *Linn.* sp.
Triplecia cf. insularis, *Eichw.* sp.
Ptilodictya sp.
Clathrodictyon sp.

This limestone certainly belongs to the Wenlock series, but it is impossible to say whether it corresponds to the horizon of the Wenlock Limestone in the typical district, although such a correlation would seem plausible.

To the south of the limestone, in the road leading from Pistyll Dewi over the Silurian ridge, and in streams to the immediate west of the road, are good exposures of mudstones all more or less fossiliferous. De la Beche collected from these sections, which he referred to as 'Nelson's Tower Wood,' the following forms [P.S. 296–309, 311–323]:—

Phacops (Dalmania) caudatus, *Brünn.* sp.
Phragmoceras sp.
Bellerophon trilobatus, *J. de C. Sow.*
Ctenodonta subæqualis, *M'Coy* sp.
Goniophora cymbæformis, *J. de C. Sow.* sp.
Grammysia cingulata, *His.* sp.
Modiolopsis nilssoni, *His.* sp.
Pterinea sp.
Atrypa reticularis, *Linn.* sp.
Orbiculoidea forbesi, *Dav.* sp.
Orthis (Dalmanella) elegantula, *Dalm.*
Camarotoechia nucula, *J. de C. Sow.* sp.
Cornulites serpularius, *Schloth.*

The following also are entered in the Museum register:—

Calymene blumenbachi, *Brünn.*
*Cheirurus bimucronatus, *Murch.* sp.
Spirifer (Cyrtia) exporrectus, *Wahl.* sp.

These fossils are of no zonal value, as they were collected from several exposures on different horizons.

Followed westward, the mudstones form the lower slope of Allt-Pistyll-Dewi and strike across the Valley of the Gwynon towards Middleton Hall. They are well exposed in the lower part of the stream which flows from Arbont (p. 15) to Pont Felin-gât and again just inside Middleton Park. A quarry 100 yards south-east of Middleton Lodge (the Park Lodge) shows them dipping S. 15° E. at 70°. This quarry some time prior to 1846 yielded the following fossils to De la Beche and others† [P.S. 325-336]:—

Acroculia sp.
Chonetes striatella, *Dalm.* sp.
Rafinesquina expansa ? *J. de C. Sow.* sp.
Cucullella antiqua, *J. de C. Sow.* sp.
Goniophora cymbæformis, *J. de C. Sow.* sp.
Pterinea sp.

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* Figured as *C. speciosus*, Salt., *Mem. Geol. Surv.*, vol. ii, pt. i, pl. 7, fig. 7, and as *C. centralis*, *Mem. Geol. Surv.*, dec. 7, pl. 2, fig. 16.

† *Mem. Geol. Surv.*, vol. ii, pt. i, 1848, p. 325. Murchison in 'Silurian System' figures a number of specimens from this locality.

The following are entered in the Museum Register :—

*Encrinurus punctatus, *Brünn.*
*Phacops (Acaste) downingiæ, *Murch.* sp.
*Phacops (Dalmania) longicaudatus, *Murch.* sp.
*Orthoceras bullatum ? *J. de C. Sow.*
*Pleurotomaria lloydi ? *J. de C. Sow.* sp.
*Pterinea sowerbyi, *M'Coy*
*Pterinea lineata, *Goldf.*
*Atrypa reticularis, *Linn.* sp.
*Chonetes striatella, *Dalm.* sp.
Strophomena pecten, *Linn.* sp.
*Cornulites serpularius, *Schloth.*
*Tentaculites ornatus, *J. de C. Sow.*

To the west of Middleton the now attenuated outcrop of the Silurian rocks is best seen in a stream at Cwm-Forgan, 400 yards north by east of Wern-boncam. The beds dip steeply and are fairly fossiliferous. There are no exposures of importance to the west of this locality, and the last of the mudstones disappears in a little more than half a mile.

H. H. T.

The Lletty Grit.—Above these horizons and about half-way across the Silurian outcrop a well-marked band of white and pale-yellow fine-grained grit or sandstone can be traced more or less continuously. As it is best seen at Lletty, on the Neath road two miles from Llandilo, we have called it the Lletty Grit.

Sandy material on or about this horizon first comes in near Llwyn-bedw, where mudstones containing sandstone bands up to 6 inches thick are exposed in a lane about 200 yards south of the house. Thence a slight feature brings us to Tre-iorwg Farm, where fine yellow grit-bands can be seen in the yard. Prof. T. T. Groom has observed quartzite in the Llandilo-Trapp road at a point 400 yards south-east of the gateway of Maes-Evan Farm. The rock is better seen in an old quarry in a lane at 100 yards south of Ty-newydd Farm, where it consists of hard grey calcareous sandstone weathering brown, and 72 feet thick. It next appears in a dingle at 170 yards south-west of Pennsylvania Farm, where it consists of soft fine yellow micaceous sandstone. It is just visible in a ditch east of Cil-y-weunydd north of Storm Hill, and can be traced thence to Lletty, where it has been quarried near the house and appears to be about 200 feet thick.

It is thrown northwards by a large fault which passes Meusydd-hirion in a northerly direction, and, west of the Cennen, is well exposed at Tir-glan-Cennen ; it has been quarried on the Llanelly road, and forms some wooded slopes on the edge of Golden Grove Park, where it shows evidence of disturbance.

In this immediate neighbourhood there are one or two other similar grit-bands at a slightly lower horizon ; one has been quarried at 130 yards south-west of Pwll-llaca ; the other is somewhat higher and has been quarried just within Golden Grove Park immediately west of the ruins of Wenallt. It is possible, however, that this last exposure should be referred to the Lletty Grit.

T. C. C.

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* Wyatt-Edgell collection.

The Lletty Grit, which has an average thickness of about 180 feet, is poorly exposed in Golden Grove Park, but shows itself at the head of the most westerly dingle mentioned on p. 44 to the south of the clump of fir-trees. A little to the west of this exposure it is thrown northward by the Keeper's Lodge Fault (p. 180), but may be easily picked up again outside the park wall. It is well exposed at a sudden bend in the main road to the south of Llanfihangel. The grit may be traced from this point in either direction, eastwards to the park wall and westwards into the wood flanking the road.

About a quarter of a mile to the west it may be seen crossing two deep dingles at the eastern end of Allt-y-berach and also to the immediate south of Berach Farm. In a wood where the old Camp of Pen-y-graen is situated the grit takes a sudden bend southwards, but it recovers itself in about 100 yards and continues with its original strike of W. 10° to 20° S. to the south of Glan-Shon-Harri Farm and along the top of Allt-pant-mawr.

A little to the north-west of Cefn Berach chapel it is broken by a fault which cuts both Silurian and Old Red Sandstone (p. 180). To the west of the fault the outcrop may be traced as far as the main road to Dryslwyn, but there the Lletty Grit seems to pass below the Old Red Sandstone (p. 55).

H. H. T.

The mudstones above the Lletty Grit exhibit the same general characters as those below it for some distance, but towards their top they alternate with tough indurated mudstone, in bands seldom exceeding 6 inches in thickness ; there is little doubt that this part of the series should be assigned to the Ludlow group.

The upper part of the group is exposed in the yard at Hafod Farm (half-a-mile east of Llwyn-bedw), and the section is continued up the lane ascending the escarpment to the south. At about 200 yards south of the farm we obtained *Lingula lewisi* ?, J. de C. Sow., identified by Mr. E. T. Newton. [Hafod, Carm. 42 NW. W λ 5, T.C.C. 368, 369].

The beds are sufficiently hard to have formed a steep scarp, the base of which can be traced south-westward from Hafod nearly as far as the Llandilo-Trapp road ; they are visible in places, and have been quarried by the side of a farm-road ascending the escarpment south of Llwyn-bedw ; at this quarry (700 yards south of Llwyn-bedw) we obtained *Stropheodonta* cf. *filosa*, J. de C. Sow. sp., *S. applanata*, Salt. sp., *Orthis* (*Dalmanella*) *elegantula*, Dalm., and *Beyrichia klœdeni*, M'Coy, identified by Mr. E. T. Newton [Carm. 42 NW. W λ 1, T.C.C. 385–393].

The beds crop out in the road between Cil-y-weunydd and Storm Hill Lodge, and again at Allt-du, on a cross-road 200 yards farther west, a locality referred to by J. Phillips.* Thence they can be traced westwards to a cutting on the railway at Meusydd Mill, where they are in a vertical or slightly inverted position, and rolling somewhat in strike; at the north end of the section several of the harder bands are as much as 3 feet thick. West of this they have been cut through by the Llanelly road, a section referred to by J. Phillips* as 'Swansea Road.' T. C. C.

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* *Mem. Geol. Surv.*, vol. ii, pt. i, 1848, p. 324.

The mudstones and sandstones above the Lletty Grit are well exposed at the extreme south of Golden Grove Park. They are of a dark-green colour and contain a few thin yellow and white grits. A quarry close to the park wall 250 yards east by south of the entrance into the park from the Dryslwyn road shows a good section in fossiliferous vertical mudstones. To the west of the Keeper's Lodge Fault these mudstones cross the main road to Llanfihangel Aberbythych near where the branch road to Capel Berach leaves it, and appear at a few places between this point and Llanfihangel. This road-section is referred to by Phillips under the title of 'Golden Grove, the road to Bryn-bâch.'† Bryn-bâch is marked on the Old Series Map, Sheet 41, but no house of that name now exists.

Phillips's 'Golden Grove, 2' is probably in the pale sandstones (Lletty Grit) which occur at the bend in the road to the south of Llanfihangel. His 'Golden Grove, 3' is probably a section in vertical mudstones with a strike of W. 10° S. which outcrop in the western hedge-bank of the main road a little north of the branch road to Capel Berach. 'Golden Grove, 4' is a large disused quarry 200 yards from the main road and on the north side of the branch road opposite the house called Tyle. This quarry shows inverted fossiliferous beds dipping apparently N. 15° W. at 80°, which were placed by Phillips in the Upper Ludlow. At the corner of the branch road is a highly fossiliferous yellow-weathering rock which represents almost the upper limit of the mudstones. The road shows a good section for nearly half a mile, all the beds being more or less fossiliferous. These mudstones may be traced westwards between the Lletty Grit and the Old Red Sandstone as far as Plas-bâch, one-third of a mile to the west of Cefn Berach Chapel, where their gradual overstep by the Old Red Sandstone is completed. H. H. T.

Grammysia Bed.—Above the green mudstones east of the Cennen Valley a well-marked band of dark purple-grey sandstone, hard and flaggy, characterised by an abundance of *Grammysia*, can be traced for some miles. It enters the map near Cennen Tower (halfway between Llandilo and Gwynfe), where it is quarried for roadstone, and can be traced to Storm Hill. On account of its durable nature and the like character of the overlying Trichrûg Beds it forms the northern face of an elevated ridge dividing the basin of the River Cîb on the north from that of the Cennen on the south.

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* *Mem. Geol. Surv.*, vol. ii, pt. i, 1848, p. 326.

† *Ibid.*, p. 325.

The rock is excellently exposed south-east of Llwyn-bedw, always in a vertical or slightly inverted position. It has been occasionally quarried for roadstone and walling purposes. A quarry 300 yards south of Hafod contains a highly fossiliferous band which yielded *Homalonotus knighti* ?, König; *Phacops* ?, *Orthis* (*Dalmanella*) *elegantula*, Dalm., *Spirifer elevatus*, Dalm. sp., *Pterinea retroflexa*, Wahl. sp., var. *naviformis*, Conrad, and *Grammysia* sp., identified by Mr. E. T. Newton. [Carm. 42 NW. W λ 3, T. C. C. 378–384].

The *Grammysia* Bed rests with well-defined base on the uppermost Ludlow mudstones ; but south-westward it loses its characteristic colour and hardness and appears to pass laterally into the ordinary Ludlow mudstones, and we could not trace it west of Storm Hill. West of the Cennen, in the Llanelly road, a complete section from the mudstones up into the Trichrûg Beds shows that no obvious representative of the *Grammysia* Bed is present.

Trichrûg Beds.—A remarkable group of unfossiliferous red and yellow rocks overlies the *Grammysia* Bed ; they form the central ridge of the mountain of Trichrûg, three miles south of Llangadock, and can be followed thence by Cennen Tower to the ridge south of Hafod, along which they can be examined in detail. They consist in the lower parts of hard yellow or pinkish-yellow quartzites, with thin seams of soft red sandstone and red sandy marls ; the higher beds are dull red and brown quartzitic grits, sandstones and sandy marls, mostly pebbly. They probably pass up into softer beds, rarely visible but presumably marls, which occupy a hollow which intervenes between the hard beds just described and the overlying Tilestones.

The outcrop of the Trichrûg Beds can be examined at many points, *e.g.*, by the side of the Llandilo-Trapp road near the Unitarian Chapel ; at Crûg-du Bank north of Cefn-cethin, and at Storm Hill, where the rock has been quarried. West of this point the upper part tends either to take on a yellow colour or else gradually to thin out : for by the side of the Llandilo-Neath road on the east side of the Cennen Valley, there is room, between the yellow Grits and the overlying Tilestones, for a very thin band of dull-red rocky marls containing small pebbles as a representative of the much thicker red beds of the country to the east. On the Llandilo-Llanelly road on the west side of the valley 4 feet is the thickness of a bed of red marl in a similar position.

West of this the Trichrûg Beds form Warren Golden Grove and a ridge on the south of the Park ; they are well-exposed in a quarry a few yards north of the altitude point 616 on the map, the section showing thick- and thin-bedded greenish-yellow quartzitic sandstone, with some quartz pebbles, and partings of green marl. The beds dip N. 10° E. at 80°.

From a total thickness of 600 feet (yellow beds 200, red 400) south of Hafod the group has dwindled to 360 at Storm Hill, 230 (with only a trace of red beds) at the Neath road, 240 at the Llanelly road, and 200 at Warren Golden Grove. T. C. C.

in their westerly prolongation to the south of Golden Grove the Trichrûg Beds have thinned down rapidly to about 90 feet in thickness. The yellow and white grits of which they consist may be traced by way of Warren Golden Grove from the Llanelly Road, through the southern part of the park, where there are several old quarries, to the Keeper's Lodge Fault (p. 180) which crosses the eastern end of a small peat-bog just outside the park wall. On the western side of the fault the beds continue to thin with equal rapidity, and disappear before they reach the main road to Llanfihangel, and before they come into contact with the Old Red Sandstone (p. 55).

H. H. T.

Tilestones.—These yellow highly micaceous sandstones and grits succeed the Trichrûg Beds and were formerly wrought very extensively for tiles.

At Cilmaenllwyd Quarry, north-east of Trapp, they are about 150 feet thick; at the south-west end of the quarry the following descending section was measured across the vertical strata :—

Cilmaenllwyd Quarry.

		Ft.
Tilestones	Flags, micaceous, pebbly, green, seen for - - - - -	12
	Tilestones (quarried), highly micaceous green sandstone -	10
	Sandstone, pebbly, greenish-yellow, not worked - -	40
	Tilestones (quarried), as before - - - - - -	32
	Sandstone, pebbly, greenish-yellow, seen for - - -	30
		124

The pebbly sandstones probably extend some few feet both upwards and downwards.

There are thus two bands of material suitable for tiles, and the rock has been quarried so as to leave two parallel vertical-sided trenches in places 10 or 15 feet or so deep, but often more or less filled up with the waste from later workings. The walls of the quarries, formed of bedding-planes, here and there show minute wrinkling parallel to the strike, and grooving parallel to the dip, the latter possibly due to the action of pebbles during the folding. Among the debris are many pieces of soft brown ochreous earth, probably a decalcified earthy limestone, crowded with casts of gasteropods and lamellibranchs.

From Cilmaenllwyd Quarry the outcrop of the Tilestones can be traced by numbers of old quarries, of which may be mentioned those at the Unitarian Chapel on the Llandilo-Trapp road, and others at Onen-fawr a little farther west. At Park Nursery, one-third of a mile west of the chapel, we again see that the workable tilestone is confined to two bands, the upper 4 feet, the lower 12 feet, thick, with an intermediate band of pebbly sandstone

12 feet thick. The quarries 200 yards east of Storm Hill Lodge yielded a number of fossils to J. Phillips;* the following are preserved in the Museum [P.S. 217–229]:—

Cyrtoceras sp.
Anodontopsis bulla, *M'Coy*
Cucullella antiqua, *J. de C. Sow.* sp.
Goniophora cymbæformis, *J. de C. Sow.* sp.
Modiolopsis sp.
Pterinea sp.

Entered in the Museum Register:—

Bellerophon trilobatus, *J. de C. Sow.*
Holopella gregaria, *J. de C. Sow.* sp.
Platyschisma helicites, *J. de C. Sow.* sp.
Anodontopsis sp.
Ctenodonta sp.
Lunulicardium sp.
Lyrodesma sp.

West of this there are old quarries by the side of the Llandilo-Neath road on the east side of the Cennen Valley, and also on the west side at Llethr-garw and Warren Golden Grove, but here the workable stone appears to have greatly deteriorated in thickness and quality.

T. C. C.

From the Swansea Road this micaceous series follows the strike of the Trichrûg Beds described above and has been quarried in Warren Wood on the south side of Golden Grove Park. It is obvious that here the Tilestones are gradually overstepped by the Old Red Sandstone, but they appear to cross the main road to Llanfihangel, and to continue for a few hundred yards before finally disappearing. Their outcrop therefore continues a little further to the west than that of the Trichrûg Beds.

H. H. T.

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* *Mem. Geol. Surv.*, vol. ii, pt. i, 1848, p. 326.

CHAPTER V.

OLD RED SANDSTONE.

By T. C. Cantrill and H. H. Thomas.

Introduction.

The Old Red Sandstone in the ground under description consists of the following subdivisions in descending order :—

	Ft.		Ft.
Grey Grits - - - - - - - - - -	0	to	30
Brownstones, with Pebbly Beds and Plateau Beds	750	to	1,600
Senni Beds - - - - - - - -	600	to	1,250
Red Marls, with Green Beds at base - - - -			4,500

Red Marls.—These consist of red marls, frequently hard and sandy, and sometimes mottled and spotted with green colour. They contain a few thin beds of soft micaceous dull-red and green sandstone and of harder gritty sandstone. Through some of the marl-beds small calcareous nodules are scattered, or arranged in pipes perpendicular to the bedding, and occasionally the marl appears to have been washed away immediately after deposition, leaving a rock composed almost wholly of nodules, thus constituting a conglomeratic cornstone. Bands of this type of cornstone occur between Gwynfe and Trapp, but seldom exceed 2 or 3 feet in thickness. Compact limestones, such as occur in Monmouthshire,* and near Llanstephan in Carmarthenshire, are absent.

In the eastern part of their outcrop the Marls are red to their base and pass down into the Tilestones, but on the eastern side of the Cennen Valley south of Llandilo a band of greenish-yellow highly micaceous sandstones sets in at their base and persists westwards, and from Golwg-y-byd, south of Llanfihangel Aberbythych, has been distinguished on the map by colour. These beds attain a thickness of 450 feet. At the same time they gradually overstep every member of the Silurian system in succession, and ultimately lie directly on the Arenig rocks south-west of Llanarthney. Upwards the Marls pass by alternation into the Senni Beds. Their thickness is difficult to determine on account of the possible existence of strike-faults and folds, but may be 4,500 feet including the green basal beds.

No fossils have been obtained save a few large ostracods at 5 or 6 feet above their base at Cilmaenllwyd Quarry.

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* A. Strahan, 'The Country around Newport, Mon.,' 1899, p. 18, *Mem. Geol. Surv.*

Senni Beds.—This group of sage-green and dull-red sandstones and micaceous flags, with marls and conglomeratic cornstones, was first met with in the Senni Valley in Breconshire. In the map under description they are best seen in the Cennen Valley east of Trapp. The sandstones are occasionally quarried for walling and paving purposes. The cornstones are all conglomeratic and do not exceed 6 feet in thickness. A specimen of grey-green conglomeratic cornstone from the Senni Beds on the south-west slopes of Castell Careg Cennen Hill at 350 yards west of Pant-y-ffynnon Cottage was sliced for the miscroscope and is thus described by Mr. H. H. Thomas :—

E. 4257.—Angular quartz-grains, a little muscovite, a few grains of felspar, and brown tourmaline, set in a fine calcareous groundmass which has locally become crystalline. The rock also contains what look like plant-remains and large fragments of non-crystalline limestone.

The Senni Beds have yielded no fossils in the region under description, but are proved to be of Lower Old Red Sandstone age by the occurrence of *Pteraspis*, near Kidwelly.*

Their green colour gives place upwards to a dull-red, and they graduate into the Brownstones, but their micaceous character and less brilliant colouring serve to distinguish them broadly from those rocks. Their thickness south of Gwynfe cannot be less than 1,250 feet.

Brownstones.—These consist of bright-red marls and brown sandstones. The latter are less fissile and flaggy and are tougher, more gritty and open-grained than those of the Senni Beds. Westwards the sandstones dwindle and the Brownstones become scarcely distinguishable lithologically from the Red Marls.

The upper beds of the Brownstones present some features of especial interest. In the Brecknock Beacons † the red sandstones and marls where the section is most complete are capped by some 50 feet of red quartzitic conglomerates and pebbly grits which have produced the characteristic plateau scenery of those hills. These plateau-beds gradually dwindle westwards and disappear at the river Clydach, south-east of Gwynfe, apparently being overstepped by the Grey Grits which thus come to rest on somewhat lower horizons of the Brownstones. It is difficult to avoid the conclusion that an unconformity at the base of the Grey Grits sets in in the north-east corner of the map and continues westwards. The Grey Grits are closely connected with the Carboniferous Limestone and are presumably of Upper Old Red Sandstone age, as from evidence in Gower are the Brownstones also, to which they are there conformable. The unconformity therefore is probably local, and does not represent that which elsewhere separates the Upper from the Lower Old Red Sandstone, and of which we have detected no evidence in the ground under description.

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* E. Dixon in 'Summary of Progress' for 1903, p. 38, *Mem. Geol. Surv.*

† T. C. Cantrill in 'The Country around Merthyr Tydfil,' 1904, p. 6, *Mem. Geol. Surv.*

South of Trapp some pebbly red and olive-green grits come in at the top of the Brownstones and expand westwards to a thickness of 500 feet. These do not represent the plateau-beds but belong to a lower horizon; they indicate a change of conditions, marls and sandstones of the ordinary Brownstone type passing horizontally into coarse and pebbly sandstones.

The thickness of the Brownstones (including the plateau-beds) varies from about 1,600 feet in the east to about half that thickness in the west.

Grey Grits.—These are a thin group of grey, yellow, and olive-green quartzitic grits and conglomerates which immediately underlie the Carboniferous Limestone Series in the eastern part of the map. Where pebbly they closely resemble the basement-beds of the Millstone Grit. They are traceable as far west as Llygad Llwchwr, and are nowhere more than 30 feet thick; on the map they are not shown west of Breast Cwm Llwyd.

T. C. C.

The overstep of the Old Red Sandstone on to the older strata begins to make itself evident to the immediate south of Golden Grove, but as long as the Tilestones persist is far from easy to observe. A little to the west, however, after the disappearance of the Tilestones, it becomes more obvious, and a glance at the map will suffice to show how continually the lower limit of the Old Red Sandstone approaches the outcrops of lower members of the Silurian series. Between the Keeper's Lodge Fault and the main road to Dryslwyn, a distance of a little over two miles, it passes across a series of beds at least 1,000 feet thick and comes into contact with the Lletty Grit. This overstep continues, and, although there is nothing which might be called a conglomerate at the base, and though there appears more or less perfect parallelism between the two formations, it becomes obvious when the beds are mapped for several miles. From the Dryslwyn road westward the lower limit of the Old Red Sandstone rests on the lower series of Silurian mudstones (p. 45), and in the neighbourhood of Middleton Hall it is probable that only a part of the Wenlock Series is left. To the west of Middleton and a few hundred yards west of the main road to Porth-y-rhyd the outcrop of the Silurian rocks has dwindled to a very narrow strip and has entirely disappeared before the edge of the map is reached, leaving the Old Red Sandstone in contact with the *Ogygia marginata* Beds of the Arenig Series. De la Beche, recognising and fully appreciating this overstep, remarked that 'it becomes such that from near Middleton Hall to the vicinity of Carmarthen, it [the Old Red Sandstone] rests on the lower Silurian [Ordovician] rocks, covering up the higher Silurian Beds. . . . Though this overlap may appear considerable when we regard the thickness of the beds observed at the western part of Carmarthenshire, it is really very gradual viewed as a whole; so much so, that where the beds are disturbed, or elevated, at considerable angles near the junction of the rocks, the unconformable relation of one set of beds to the other is only apparent on a great scale, and by embracing a considerable area.'* H. H. T.

Red Marls.

East of Llandilo the greenish-yellow sandstones forming the top beds of the Tilestones pass upwards within 10 feet or so into reddish-yellow highly micaceous soft sandstones, followed by dull-red highly micaceous sandy marls with large quartz-grains. These last, the lowest beds of the Old Red Sandstone, contain at Cilmaenllwyd Quarry casts of giant ostracods,† referred by Mr. E. T. Newton to *Leperditia* n. sp. ?; and in the Survey collection *Lingula cornea*, J. de C. Sow. [P.S. 242–243] is preserved from this locality.

These beds form the base for some distance westward from Cilmaenllwyd Quarry, but between Storm Hill and the Cennen Valley greenish-yellow highly micaceous sandstones, much like the Tilestones, come in on this horizon. In the Llandilo-Llanelly road, on the west of the valley, strata of this description with red-tinged marls pass down into the Tilestones, and are succeeded by green marls (some red-mottled) with green sandstones. It is evident therefore that the conditions for the formation of red marls set in gradually, and that so far as regards the Llandilo district there is a passage, though a rapid one, from the Tilestones into the Old Red Sandstone.

East of the Cennen Valley the Red Marls contain occasional sandstone bands, thin, but unusually coarse-grained. One such band crops out in a lane 100 yards north of Lan Farm, north-east of Trapp, at about 390 feet above the base; another is exposed in a lane north of Pen-y-waen, within some 30 feet of the base; in Onen-fawr farmyard (a little west of the chapel on the Llandilo-Trapp road) the red marls within 150 feet of the base contain several thin bands of pink and green coarsely-granular sandstone. In Cwm-baget farmyard, north-west of Derwydd Road Station, bare red marls are well-exposed, and contain a 3-foot band of coarse white quartzose sandstone.

Occasional thin bands of green sandstone occur some distance up in the Red Marls; one or two such bands lie about 2,400 feet above the base in the neighbourhood of Trapp; thus green sandstone appears in the river Camnant west of Ty'r-doppa and forms a waterfall; in or about the same line of strike similar rock appears farther west at Pant-y-dalfa, and again near the chapel two-thirds of a mile north-east of Trapp, the thickness nowhere exceeding 30 feet. In a brook 300 yards west of Careg-Cennen House, soft green sandstones and marls, 15 feet thick, in red marls, are exposed, and a small quarry 200 yards north of Blaen-y-Cwm Farm (half-a-mile east of Cefn-cethin) has been opened in micaceous green sandstone exposed for 15 feet. These green beds closely resemble the green sandstones of the Senni Beds, and the possibility of their being a narrow infold of these has not been lost sight of, but the evidence available points to their marking a green phase about half-way up in the Red Marls.

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* *Mem. Geol. Surv.* vol. i, 1844, p. 24.

† These were incorrectly spoken of as *Lingulæ* in the 'Summary of Progress' for 1901, p. 38, *Mem. Geol. Surv.*

The cornstones are poorly represented as compared with Herefordshire and Monmouthshire, and are too thin to be represented on a one-inch map. Such as occur are all of the conglomeratic variety † and seldom exceed 2 or 3 feet in thickness. Examples may be met with between Gwynfe and Trapp in the fields south of Capel-y-maen, and not far below the Senni Beds. West of this locality no cornstones have been observed.

The Red Marls, which present no other noteworthy lithological varieties, are well exhibited in the brooks which flow northwards from the Black Mountain; in the neighbourhood of Glan-Toddeb; and especially in the fields south of Capel-y-maen and north of Castell Careg Cennen, and along the course of the Cennen below Trapp. There is an excellent section in the Llandilo-Llanelly road north of Rhyd-y-ffynnon, where the Tilestones (p. 52) pass up into the basal beds of the Old Red Sandstone.

T. C. C.

A group of highly inclined green sandstones and marls which occurs to the immediate south of the Tilestones in the Cennen Valley, becomes much more massive in character and forms a good feature at the base of the Old Red Sandstone in the neighbourhood of Golwg-y-byd. From this farm westwards these green beds are shown on the map as a continuous outcrop. This basal group is about 450 feet thick and consists of fissile sandstones and marls with a prevailing green tint, but with an occasional red bed. The green colour is due to the presence of a quantity of chloritic material, and the same is in a measure true in the case of other green beds in the Old Red Sandstone. The basal beds are well exposed along and near the road from Golwg-y-byd to Cefn Berach chapel; to the west of the chapel they are thrown northwards (p. 180), but on the western side of the fault they cross the main road to Dryslwyn at the top of the hill, where there is a large quarry in their upper part. They share in the general bend of the rocks towards the north by way of Pen-pal and Nelson's Tower, and then turning southward again at Bigwrn, where they were quarried to build the farm-house, they form the top of Allt-Pistyll-Dewi. Passing under the drift to the east of Middleton Hall they appear again to the immediate north of the house and may be traced to the road to Bryn Hawddgar, a little to the north of Wern-boncam. At the last-named place they are thrown forward about 200 yards and re-appear in the main road to Porth-y-rhyd, where a good section is preserved in the hedge banks and in a hollow to the east of the road known as Pant-tawel. In a westerly direction they continue to form a good feature to the south of Ynys-pant. The quarries in this outcrop are referred to on p. 223.

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† A. Strahan, 'The Country around Newport, Mon.,' 1899, pp. 18, 19, *Mem. Geol. Surv.*

To the south of Golden Grove the red marls and sandstones dip steeply, and have an outcrop of about one mile in width. In their lower part they are vertical or inverted often to the extent of 20°; towards their upper limit, however, the dip falls to about 70° in a southerly direction. The outcrop retains the same width as far as the faulted outlier of Carboniferous Limestone at Bryn-yr-odyn, but from this point to the south of Middleton Hall it widens considerably, in consequence of the upper part of the series dipping much less steeply than before, the inclination falling as low as 25° to 30°; the lower part of the series, however, still keeps for the most part vertical or very highly inclined. The rocks are in general well exposed but not continuously; a good section in their upper part occurs in the bed of the river Marlais 1½ miles south of Golden Grove.

H. H. T.

Senni Beds.

Above the Red Marls comes a group of micaceous sandstones, green below, dull-red above, with thin conglomeratic cornstones, which has been named after Glyn Senni.* It occupies the cultivated slopes lying at the foot of the great Brownstone escarpment.

The Sawdde-fechan above Llan (Sheet 212) crosses these strata in a succession of cascades; the river Clydach from Pant-y-bedw downwards, and the Rhuddel also which joins the Clydach east of Glan-Toddeb, both give a good view of them. The Rhuddel for one-third of a mile above its junction with the Clydach flows over the Red Marls, but farther up it traverses the Senni Beds by several cascades and through a cliff-sided gorge excavated along the dip-joints. Green sandstones with some green marl and dull-red sandstone form the walls of the gorge; at its northern end there is a green conglomeratic cornstone three feet thick, and at the middle another, varying from three feet six inches to six feet. Still higher up, the stream shows micaceous dull-red sandstones and marls belonging to the higher part of the Senni Beds.

In the Dwfn above Ty'r-cwm similar sections are exposed; others may be examined between Gelli-Bevan and Pen-y-bwlch.

West of Blaen-Cennen the lower green parts of the Senni Beds are frequently visible on the high ground south of Capel-y-maen and also in the bed of the Cennen; they consist of the usual green micaceous flaggy sandstones, with some thin conglomeratic cornstones. On the south of the river the slopes leading up towards the Black Mountain are occupied by the red upper beds. The base of the Senni Beds can be traced with ease along the line shown on the map from Blaen-Cennen to Castell-Careg-Cennen, where it is interrupted by a fault; at Trapp it reappears, and green sandstones are exposed at Caerau and Heol-fawr, and have been quarried at Llyn-y-beddau Farm. North of Llandyfan the beds crop out in the road at Goetre and have been quarried at Pen-rhiw.

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* T. C. Cantrill in 'The Country around Merthyr Tydfil,' 1904, pp. 5, 8, *Mem. Geol. Surv.*

West of the Llandybie valley they are exposed in the right bank of the Marlais below Derwydd, and about Clyn-côch.

The green sandstone of the Senni Beds constitute almost the only part of the Old Red Sandstone of the district which is of any use for building-purposes (pp. 221–223).

T. C. C.

About one mile to the north of Pentre-gwenlas this series of green and red micaceous sandstones makes an outcrop of about 350 yards in width, the beds dipping at about 70° in their lower part and 55° in the upper. It may be traced westward to the north of Carmel, where it is probably thrown forward about 100 yards by the fault which, to the south, displaces the Carboniferous Limestone. The base may then be traced as far as the Pysgodlyn to the east of Bryn-yr-odyn, after which its place is taken as far as Garn-lwyd by the great disturbance which lets down the outlier of Carboniferous Limestone. It then emerges from the line of disturbance, but on its northern side, and crosses a dingle to the north of Pont-cwm-hebog, half a mile to the north-east of Porth-y-rhyd.

The Bryn-yr-odyn disturbance has the effect of repeating part of the Senni beds to the north of Porth-y-rhyd which, together with a series of low dips, accounts for an outcrop more than one third of a mile in width.

The upper limit of this series is obscure from the north of Carmel to the alluvium of the Gwendraeth-fâch, partly through lack of exposures and partly through the thick drift which covers the southern side of the Gwendraeth-fâch valley. The best exposures of the Senni Beds are in the road to the south of Bryn-yr-odyn leading to Bryn-du-isaf, and in the valley of the Gwendraeth-fâch from a mile west of Maes-y-bont to the alluvial tract at Porth-y-rhyd.

H. H. T.

Brownstones.

In descending the Twrch-fechan (in the north-east corner of the map) we get an ascending sequence of the red marls and sandstones of the Brownstones. At 200 yards above its confluence with the Twrch the stream passes onto the plateau-beds, consisting of pebbly red quartzitic grit 20 or 30 feet thick, succeeded by about 120 feet (an unwonted thickness) of fine-grained hard red sandstone ; it then crosses the outcrop of the Grey Grits just before falling into the Twrch. This is one of the best localities for examining the relations of the Grey Grits to the plateau-beds.

At the upper end also of the valley, at Pen-rhiw-gôch, the plateau beds occupy the same position relative to the Grey Grits.

North of Careg-yr-ogof (Sheet 212), the same phenomena are presented in the ground lying east of Carn-y-cigfran, where the red pebbly grit marking the base of the plateau-beds forms a line of low crags dipping towards the outcrop of the Grey Grits ; the red pebbly grit which is about ten feet thick contains pebbles of white and of pale pink vein-quartz, and occasional pale red and pale green quartzite, ranging in size up to four inches. This grit is followed by hard light-red sandstones, red flaggy sandstones, and sandy shales. The thickness of the plateau-beds here is only about 60 feet as compared with some 150 feet at the mouth of the Twrch-fechan.

On the west side of Gareg-lâs the plateau-beds are still thinner ; in the Sawdde-fechan the pebbly beds are not exposed, but a little to the west they form a line of crags, between which and the overlying Grey Grits only a few feet of red sandstones intervene. The same thing obtains along the west side of the fault at Blaen-Clydach. Still farther west where the Grey Grits cross the Clydach they rest directly on a band of pebbly red grit seven feet thick, which is all that separates them from the ordinary red sandstones and marls of the Brownstones. West of this point the plateau-beds are never again exposed ; the Grey Grits resting directly on lower horizons of the Brownstones.

The conclusion seems unavoidable that the Grey Grits gradually overstep the plateau-beds and other parts of the Brownstones westwards ; and this would support the view that the Grey Grits are the natural base of the Carboniferous system. On the other hand the Grey Grits thin out, or are overlapped by the Lower Limestone Shales, a few miles farther west (pp. 61, 66).

A red cornstone-band three feet thick was noted, as in an unusual position, in the Clydach on an horizon 60 to 70 feet below the base of the Grey Grits, and another and thinner band at 20 to 30 feet below the Grey Grits.

West of the Clydach numerous runnels descending from Rhiw-wen afford sections above the Llangadock road ; stone for the new church at Gwynfe (opened in 1899) was obtained at the seventh milestone from Llangadock.

In Nant Oesglyn above Gelli-bevan several of the sandstone beds are 20 to 30 feet thick ; a few thin cornstones are present ; one of which, 1 foot 6 inches thick, is only 3 feet below the Grey Grits (p. 66).

The Brownstones immediately below the Grey Grits here are shown in the following section :—

Nant Oesglyn.

		Ft.	In.
Grey Grits (p. 66).			
Brownstones (top of)	Marls, red, rocky	3	0
	Cornstone, conglomeratic, green and red, forming a cascade	1	6
	Sandstone, hard, light-green, calcareous	5	0
	Gap	6	0
	Marls, hard, red		

The conglomeratic cornstone, which is identical in character with those abundantly present in the Senni Beds, is dark olive-green in colour, and consists of small subangular and rounded fragments (up to ·75 inch) of brown and grey amorphous limestone, and, more rarely, fine-grained sandstone and marl, in a dark olive-green calcareous sandy matrix. The limestone pebbles weather away on the exposed surfaces of the rock and give it a characteristic pitted appearance.

A cartroad obliquely ascending Banc Wern-Wgan shows how marls predominate over sandstones ; there are only a few feet of sandstones at the top.

At the eastern extremity of the copse north of Beddau'r Derwyddon the uppermost Brownstones contain a band of grey sandstone 6 feet thick weathering yellow, in red marl ; at the western end of the same copse a cartroad shows the following descending section :—

		Ft.	In.
Grey Grit.	Sandstone, quartzitic, olive-green, some small pebbles	6	0
Brownstones (top of)	Marl, red	10	0
	Shales, buff, micaceous	2	0
	Sandstone, grey	3	0
	Sandstones and marls, red, mottled grey		

At Cwrt-bryn-y-beirdd the Lower Limestone Shales rest directly on red marls, so that the Grey Grits have either thinned out or been overlapped somewhere near Llygad Llwchwr. Two-thirds of a mile west of Cwrt-bryn-y-beirdd however there appear at the top of the Brownstones, some olive-green grits (not quartzitic) containing quartz pebbles and rolled fragments of olive-green marl, succeeded by pebbly coarse red sandstones. This pebbly group has been traced westwards for many miles.

South of Tir-y-pant two small openings a few yards north of the base of the Carboniferous Limestone Series show respectively green gritty sandstone, and 3 feet of hard green pebbly sandstone overlying 2 feet of yellowish-green fissile micaceous pebbly sandstone ; these belong to the pebbly group.

The floor of the lane ascending the scarp south of Tan-y-cincoed affords the section given below :—

Tan-y-cincoed.

		Ft.	In.
Main Limestone.	14. Dark limestone		
Lower Limestone Shales, 79 feet.	13. Dark shales, rusting brown and yellow, extending for 26 yards down the lane	60	0
	12. Ochreous soil, possibly a weathered limestone	4	0
	11. Soft buff mudstone (? a decalcified rock)	4	0
	10. Hard greenish-yellow grit	3	0
	9. Yellow rotten sandstone or soft buff mudstone like 11, passing down into 8	3	0
	8. Greenish-yellow sandy mudstones with large well-rounded quartz-grains	5	0
Grey Grits ? 4 feet.	7. Hard fine-grained greenish-grey sandstone and dark very hard grit, with small quartz-pebbles	4	0
Brownstones (part).	6. Yellow micaceous sandy shales and sandstone, with very small mica-flakes, lowest layer mottled pale-red	4	0
	5. Gap of about	12	0
	4. Red sandstone and marl, about	20	0
	3. Yellow micaceous sandstone, seen for	30	0
	2. Gap		
	1. Red sandstone and marl		

The base of the Lower Limestone Shales, as determined above, seems the most probable line; but possibly it should be drawn at the bottom of 6, for grits such as 7 are not unknown in that group. One fact, however, comes out clearly, that at least 30 feet of yellow sandstone lies below red sandstone and marl of the ordinary Brownstone type, and may be grouped with the pebbly olive-green beds which we have seen come in a little to the east. Whether 7 should be identified as the Grey Grits is open to question, but it differs markedly from the yellow micaceous sandstones, 3. If the section has been interpreted aright, the pebbly group at the top of the Brownstones, represented by beds 6 to 3, occupies a lower horizon than the Grey Grits and cannot be regarded as a modified form of that subdivision.

The lower beds of the Brownstones are to be seen at Blaengweche on the east of the Llandyfan Fault, and again on the west side at Cefn-blewin and north of Rock House ; at the back of the latter is a good section of the pebbly olive-green grits which form the lowest part of the pebbly group.

Farther west, at the site of Pistyll-uchaf (north of Pistyll-bâch) and about one-third of the way up the Brownstone escarpment, a chance band of yellow sandstone 12 feet thick crops out. From Rock House the pebbly group can be traced westward in old quarries, one of which, 300 yards north-east of Pistyll-canol, displays upwards of 20 feet of olive-green sandstone with quartz-pebbles and flakes of dark greyish-green marl ; these green beds are succeeded a little to the south by red sandstones and marls of ordinary Brownstone type exposed in another quarry. Olive-green beds crop out in the lane running west from Pistyll-canol, and dip towards the Lower Limestone Shales exposed a few yards east of the house (p. 77).

West of the Llandybie valley the lower beds of the Brownstones are exposed in the road west of Cil-yr-ychen and at Bwlarth; and again in the road south of Clyn-côch.

The pebbly group rapidly thickens westwards; the junction with the Carboniferous beds is exposed in a quarry a few yards north of the Cil-yr-ychen lime-kilns. The following is the descending sequence, so far as it is accessible :—

Cil-yr-ychen Sandstone Quarry.

		Ft.	In.
Lower Limestone Shales.	4. Shales, dark, dipping S. 35° E. at 28°	—	—
	3. Sandstone, dark-green, gritty	3	0
	2. Sandstone, green, fine-grained, micaceous, passing horizontally into red beds at western side of quarry	—	—
	1. Sandstones and some conglomeratic cornstones, red, current-bedded (dip S. 20° E. at 45°)	—	—

The quarry was opened for the red sandstone and cornstone; the green sandstones and Lower Limestone Shales form the upper part of the south side of the quarry. Bed 3 is presumably the base of the Carboniferous Limestone Series. One of the cornstones, 27 feet below the base of Bed 3, yielded two or three pebbles of red earthy limestone containing what are probably *Camarotœchia nucula*, J. de C. Sow. sp., *Chonetes striatella*? Dalm. sp., and *Orthis* (*Dalmanella*) *elegantula*, Dalm., as identified by Dr. T. T. Groom and Mr. P. Lake. The fossils suggest that the pebbles are of a Ludlow rock, and if so that rock must have been open to denudation during the latter part of the Old Red Sandstone period, and at no great distance away, which involves the supposition that the upper beds of the Old Red Sandstone overlap the lower.

The fine-grained green sandstones (2) which succeed are unhesitatingly referred to the Old Red Sandstone; but Bed 3 is probably a sandy base to the Lower Limestone Shales. When viewed from the eastern side of the quarry it has the appearance of gently overstepping the beds below it from south to north, in consequence of the difference of dip in the top and bottom of the quarry. The dip in the uppermost beds is confirmed by that of the limestone in the large limestone quarry to the south, but the dip of the lower beds and the appearance of overstep may be nothing more than wedge-bedding. Yet an overstep at the base of the Carboniferous rocks exists farther west and it is possible that the overstep is locally so marked as to be distinguishable in one small quarry.

The Lower Limestone Shales as shown in a tramline just above the quarry contain towards their base thin irregular bands of quartz-pebbly grit which closely resemble, if they do not represent, the Grey Grits. If so, and if there is really an overstep in the quarry below, a strong argument is furnished for classing the Grey Grits as Carboniferous.

West of a small north-and-south fault with easterly downthrow ranging from Cil-yr-ychen, the pebbly beds make a bold escarpment; yellow pebbly grits are prevalent at the base, while red beds predominate above. Above Bwlarth-fâch, red, grey, and yellowish-brown colours alternate with each other.

West of the Dinas Fault, a large downthrow west, brownish-green sandstones have been quarried in Coed Garn. The quarry west of the smithy shows 64 feet of brownish-green sandstones, generally coarse and often with many quartz-pebbles, and containing thin partings of dark green micaceous shaly marl. Pebbles of similar shaly marl are abundant in the sandstones, and their occurrence may be taken as evidence of contemporaneous erosion. The highest green bed in the quarry is a marl-band about 3 feet thick which weathers into irregular holes probably by the solution of calcareous nodules. Finally these beds are overlain by 3 or 4 feet of red sandstone. Another smaller quarry 100 yards farther west shows about 20 feet of similar beds; probably some thickness of red beds intervenes between the beds in the two quarries.

The thickness of the pebbly group at Bwlarth-fâch may be estimated at 550 feet, but west of the Dinas Fault it appears to be only 260 feet. The difference is conceivably due to the fault having brought into opposition strata which were widely separated, and on this supposition it would appear that the pebbly beds thicken rapidly to the south; but it may be partly due to a westerly attenuation also.

T. C. C.

A series of red sandstones and marls occupies the belt of country lying between the Senni Beds and the pebbly group which forms the uppermost part of the Brownstones. They are well exposed to the north of Carmel, but by far the best section is in the valley of the stream which flows in a north-westerly direction from Trawsdre-isaf to the River Gwendraeth-fâch.

The pebbly group lies next below the Carboniferous Limestone, and constitutes the highest member of the Old Red Sandstone in the district west of Llandybie. It consists of pale red, yellow, and green pebbly sandstones, which are in general considerably harder than the lower parts of the Brownstones, and form a strong feature traceable with ease. The pebbly beds maintain these characters from the north of Pentre-gwenlas westwards. From this place as far as Carmel their outcrop runs parallel to the main road, and is about 100 yards wide; which, with a dip of 36°, indicates a thickness of 130 feet. Between a point to the south of Carmel and the Maes-y-bont road, the outcrop widens considerably, through the fact that the Limestone to the south occupies a hollow in place of making an escarpment, and the pebbly beds run down the hollow with a long dip-slope, one bed occupying about half the width of the outcrop. From Maes-y-bont to the faulted wedge of Limestone at Trawsdre, the outcrop resumes its original width. These beds are not exposed to the north of Trawsdre, but they may be seen again to the west at Heol-ddu.

H. H. T.

Grey Grits.

The disappearance of the Grey Grits in part of Sheet 231 has been noted in the explanation of that map* ; there they disappeared on the west side of the Tâf-fawr Valley, but north of Ystradfellte a grit reappeared below the Lower Limestone Shales and, though too thin to be represented on the one-inch map, persists westwards. It enters the map here under description east of the mouth of the Twrch-fechan, where it is 15 feet thick and rests on the plateau-beds of the Brownstones. West of the Twrch-fechan Fault a cliff on the Twrch-fechan provides the following details :—

On the Twrch-fechan, Pen-rhiw-goch.

		Ft.	In.
Grey Grits (part)	Grit, yellowish-white, passing down - - -	4	0
	Grit, yellowish-white, very pebbly - - -	5	0
	Sandy rock, fine, buff, shaly at base - - -	0	9
Brownstones (top)	Sandy shales and marls, red		

A few yards lower down stream the Grey Grits, in the form of olive-green grit with a few small quartz-pebbles, graduate upwards into the Lower Limestone Shales.

North of Careg-yr-ogof (Sheet 212) in the ground lying east of Carn-y-cigfran the Grey Grits are exposed at the north-east and south-west ends of the peat-bog Mawnog Tyle Du, where they consist of an olive-greenish grey quartzitic rock which weathers to a light rusty-red and then bleaches on the surface. It contains pebbles up to 2 inches of white vein-quartz, and, more rarely of quartzite, with an occasional pebble of red jaspery rock.

Between the Sawdde-fechan and Blaen-Clydach the Grey Grits form crags and bare dip-slopes and can be examined in great detail. The quartz-pebbles range up to 2¾ inches in length. Upwards the grits, which are at least 15 to 20 feet thick, pass into yellow sandstones and sandy shales, and these in turn pass into the Lower Limestone Shales, as may be seen at the source of the Clydach.

West of the fault at Blaen-Clydach the grits make a broad outcrop bounded in places by crags and cliffs 18 to 20 feet high.

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* W. Gibson and T. C. Cantrill in 'The Country around Merthyr Tydfil,' 1904, pp. 16, 17, *Mem. Geol. Surv.*

In the Clydach they are 25 to 30 feet thick and have nearly overstepped the plateau-beds (p. 60). In a block lying on the eastern margin of the stream and some 200 yards south-east of Pont Clydach Dr. T. T. Groom in 1900 detected a fish-spine, of which he took a rubbing. Mr. E. T. Newton remarks that

> the rubbing shows about 4 inches of a slightly curved fish-spine which is about three-fourths of an inch wide at it broadest part, and was not less than 5 inches long when perfect. The whole surface seems to have been ornamented with longitudinal ridges which, however, are indistinct on some portions of the specimen. At the broadest part about 18 ridges may be counted, and they all appear to have been finely crenulated. The close resemblance which this spine bears to those which have been called *Ctenacanthus* is obvious, and when the rubbing was first shown to me I suggested the probability of its belonging to the Old Red Sandstone *Ctenacanthus ornatus* of Agassiz,* only a small fragment of which had been found in the lowest part of the Lower Old Red Sandstone of Herefordshire.

The Clydach specimen however came from the Upper Old Red Sandstone, and Mr. Newton hesitates to refer it to *C. ornatus*, Ag., or to *Climatius*,† though he keeps the opinion that it may be placed in the genus *Ctenacanthus*. He notes important differences between it and *Cosmacanthus*.

West of the Clydach the outcrop is narrower, but is marked by low crags and bare dip-slopes along the northern margin of the peaty strip occupied by the Lower Limestone Shales.

West of Clogau-mawr the grits form a cascade in Nant Oesglyn and are about 16 feet thick, (10 feet being exposed in the waterfall, below which a gap of 6 feet marks probably similar beds). In the Cennen, about one-third of a mile south-east of Blaen-Cennen Farm, they are 15 feet thick.

South of Banc Wern-Wgan they are still pebbly and are 8 feet thick, and it is noticeable that just west of the old walls of Bryniau an olive-green grit, not to be distinguished from varieties of the Grey Grits, crops out at the middle of the low ground marking the outcrop of the Lower Limestone Shales. Moreover, west of this point the Grey Grits themselves become still thinner and take the form of an olive-green quartzitic rock without pebbles and weathering yellow, as may be seen at the eastern end of the belt of copse north of the words Beddau'r-derwyddon on the map. At the western end of the copse, in a roadway, the Grey Grits are only 6 feet thick, are olive-green, and contain a few small quartz-pebbles.

Near Llygad Llwchwr they die out, though some pebbly grits in the Lower Limestone Shales (p. 64) may possibly represent them.

T. C. C.

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* Agassiz, *Poiss. Foss.*, vol. iii, p. 12. Plates, vol. iii, pl. ii, fig. 1; *also* Murchison, *Sil. Syst.*, pp. 589, 597; pl. ii, fig. 14.

† A. Smith Woodward, *Cat. Foss. Fishes*, pt. ii (1891), p. 32.

CHAPTER VI.

CARBONIFEROUS ROCKS.

Carboniferous Limestone Series.

By T. C. Cantrill and H. H. Thomas.

Introduction.

The Carboniferous Limestone Series of the area embraced by the map is divisible into the two groups which have been described in previous parts of this Memoir under the name of Lower Limestone Shales and Main Limestone. At the same time the band of shales with rottenstones, or Upper Limestone Shales, which came in between the Main Limestone and the Millstone Grit in the Tawe Valley* persists westwards across the present area. Moreover, a thin band of fine sandy cherts (plastic clay beds) appears above these near Llandybie and extends across the western part of the area. These sandy strata pass up into and usher in the sandstones of the Millstone Grit. They are too thin and too frequently concealed by Millstone Grit débris to allow of their outcrop being represented on the map.

The small thickness and the high dip of the Lower Limestone Shales over the western part of the district make it impossible to show their outcrop west of the Llandybie Valley, though they can be traced throughout the whole region under description; they contain occasional thin beds of olive-green grit and sandstone which are indistinguishable from those of the Grey Grits below.

The sequence of strata forming the various subdivisions is shown in descending order in the following table :—

General Section of the Carboniferous Limestone Series.

		Ft.
Upper Limestone Shales	Rottenstone Beds.—Dark shales with decalcified sandy and muddy limestones; about 10 ft. -	10
Main Limestone	3. Dark sandy limestone and oolite, with nodules of black chert towards the top; about 350 ft. 2. Light-grey oolite, 30 to 50 feet; a sandstone-bed (the 'honeycombed sandstone') at its base 1. Dark limestone and oolite; locally a coral-band at its base; about 300 ft. - - -	700
Lower Limestone Shales.	Shales with thin limestones, 15 to 40 ft.	30

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* T. C. Cantrill in 'The Country around Merthyr Tydfil,' 1904, p. 34, *Mem. Geol. Surv.*

Much of the rainfall on the limestone and Millstone Grit country runs down swallow-holes or percolates through into joints, and is carried off by underground channels in the limestone, but is thrown out again at powerful issues in the deeper valleys, or by the impervious shales below. Thus, a small stream sinks into a swallow-hole at the head of the Llynfell and issues as a powerful stream called Ffrwd-ar-Dwrch in the Twrch Valley. Llygad Llwchwr is the most powerful of the limestone springs ; it is thrown out on a line of fault, and drains part of the limestone country to the east. The Llandyfan spring is similarly situated.

The solvent action of this underground water in the limestone has led to the subsidence of large masses of the overlying grit, a result especially prevalent in the eastern part of the district, where a low dip prevails.*

The outcrop of the basal grit of the Millstone Grit in the same part of the district exhibits numerous swallow-holes, or funnel-shaped depressions of the surface caused by the sinking-in of the ground into underground fissures or channels in the limestone. In places, wide gentle depressions due to the same causes enclose pools, such as that on Cefn-y-Garn-Fadog north of Cwm Twrch, Llyn-y-Fignen-Felen north of Brynamman, and possibly Llyn-Llech-Owen west of Llandybie ; probably the water is held up by bands of shale interbedded in the grit.

Few accessible caves have been met with ; Careg-yr-ogof (Sheet 212) appears to derive its name from a small vertical hole 6 feet by 2 feet wide, 150 yards south-east of the summit. Llygad Llwchwr is said to have been explored for some distance from its mouth. Buckland † records that human skeletons were discovered in a cave at Pant-y-llyn, Pentre-gwenlas, near Llandybie. I have myself obtained human bones from the cave at Castell Careg Cennen.

T. C. C.

East of Llandybie.

The Lower Limestone, which runs round the eastern half of the coalfield, disappears in the Neath valley ‡ and has not been recognised in the area now under description. In its absence the Lower Limestone Shales rest directly upon, and in places seem to pass down into, the Grey Grits (p. 65).

All the lowest beds of the Main Limestone are concealed by drift in the Twrch Valley, but the dark limestone and oolite (No. 1 of the

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* *See also* T. C. Cantrill in 'The Country around Merthyr Tydfil,' 1904, pp. 47, 48 ; *also* A. Strahan in 'The Country around Abergavenny,' 1900, pp. 43–47, *Mems. Geol. Surv.*

† *Phil. Trans.*, vol. cxii, 1822, p. 171 ; *also* 'Reliquiæ Diluvianæ,' 1823, p. 166.

‡ T. C. Cantrill in 'The Country around Merthyr Tydfil,' 1904, p. 32, *Mem. Geol. Surv.*

Table on p.67), has been burnt for lime at several knolls south-east of the mouth of the Twrch-fechan ; above it the light oolite, No. 2, with the honeycombed sandstone at its base, is followed by dark limestone with chert (No. 3), introduced by rubbly and sandy beds, and containing a little dolomite. This dolomite, under the microscope, is thus described by Mr. H. H. Thomas :—

E. 4255.—Coarsely crystalline dolomitised limestone. It does not stain with logwood solution and effervesces feebly with cold dilute hydrochloric acid. The slide contains a few detrital zircons and perfect crystals of secondary quartz (·16 × ·05 mm.).

Finally the Rottenstone Beds have been dug under the grit-crags between the Gwys (Sheet 231) and Bwlch-y-ddauwynt.

At Pen-rhiw-gôch the Lower Limestone Shales exposed in the Twrch-fechan seemingly pass down into the Grey Grits (p. 65). The Main Limestone crops out here and there, but is cut up by faults.

On Careg-yr-Ogof (Sheet 212), the most northerly extension of the Carboniferous Limestone in South Wales, if we except the outlier of Pen-cerrig-calch north of Crickhowel, the sequence can be made out in great detail. The shales are about 15 feet thick, and crop under two peat-bogs. The lowest beds of the Main Limestone are sandy, and banded with grains and pebbles, ranging up to three-quarters of an inch in length, of white vein-quartz, a character specially well shown on a bridle-road due east of the summit. At about 10 feet above the base at Mawnog Tyle Du *Lithostrotion* occurs in such abundance as to constitute a coral-bed, corresponding doubtless to that traced in adjacent ground to the east,* though it lies at a gradually diminishing height above the base of the Main Limestone. Higher beds of the dark limestone and oolite (No. 1) crop out to the south. The honeycombed sandstone at the base of the light oolite (No. 2) can be detected, and a rubble-bed at the top of the oolite crops out on a path running west from Pen-rhiw-gôch. Next follows the dark limestone with chert (No. 3), and finally the Rottenstone Beds immediately below the base of the Millstone Grit.

At the source of the Sawdde-fechan the limestone emerges from a cloak of grit-débris which covers much of the western side of Gareg-lâs, and most of the sequence can be made out on the slopes of Foel Fraith. The shales, with impure limestones and decalcified sandstone, are exposed in the Sawdde-fechan, and in the head-waters of the Clydach ; they are probably upwards of 30 feet thick. The dark limestone and oolite (No. 1) with the coral-bed near its base has been quarried at the source of the Clydach, while the honeycombed sandstone, about 18 feet thick, crops out on the slopes east of Pwll Swnd, and again farther round to the west. This introduces the light oolite (No. 2), above which the dark limestone with chert (No. 3) crops out a few yards west of Pwll Swnd. The rottenstone-beds have been worked at the south-west corner of Foel Fraith, and round the Millstone Grit plateau of Cefn-y-Garn-Fadog, especially on the east at Pen-yr-alleg.

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* T. C. Cantrill in 'The Country around Merthyr Tydfil,' 1904, p. 32, *Mem. Geol. Surv.*

A strip of limestone rises unexpectedly in the bed of the Twrch east of Pen-yr-alleg ; it is almost wholly concealed under drift and alluvium ; but at a strong issue of water named Ffrwd-lâs there is an old trial-digging from which boulder-clay, rottenstone, and black limestone have been thrown out. A few yards farther up stream the Millstone Grit dips north-west at 45°, and still higher up becomes vertical, whereas to the south-east the dip is about south-east at 15°. It is probable, therefore, that the rottenstone is brought up to the surface by a faulted anticline, and that there is a downthrow to the west-north-west running along the river (pp. 81, 82).

On Foel Fawr the shales occupy a peaty flat between the bare outcrop of the Grey Grits and the bold escarpment of the Main Limestone. The dark limestone and oolite (No. 1) was formerly extensively quarried and burnt here, but lime-burning has been discontinued since 1899. South of a large quarry at the eastern end of the workings the honeycombed sandstone is about 12 feet thick and is succeeded by the light oolite (No. 2), but the higher beds are obscured by grit-débris. The rottenstone has been got at several points below the base of the Millstone Grit.

West of the Cwm Llynfell Fault a section in the Lower Limestone Shales at a roadside kiln below the eastern quarry at Clogau-bâch shows, in descending order, olive-green shales for 3 feet, red limestone 2 feet, dark shales 4 feet, blue limestone 2 feet, and shales seen for 2 feet. The red limestone is noteworthy, as similarly coloured bands are known elsewhere in the Lower Limestone Shales.

There are large quarries in the dark limestone and oolite (No. 1) overlooking the Llangadock road at the eighth milestone. The honeycombed sandstone crops out along the edge of the quarry, and about half-way along the quarry-face consists of 6 feet of sandstone with shaly partings, 6 inches of shale, and 2 feet of sandstone. It rests on the top of the dark limestone (No. 1) which here tends to become pale and oolitic. Above the honeycombed sandstone the other strata (Nos. 2, 3, etc.) follow in due order.

Westwards the same sequence obtains ; the coral-bed near the base of No. 1 disappears at Clogau-bâch, where one or two feet of dolomite are interbedded in the dark limestone a few feet above the base. The dolomite under the microscope is thus described by Mr. H. H. Thomas :—

E. 4259.—Limestone more or less completely dolomitised. Lines of staining representing boundaries of original shell-fragments pass through the crystals. The dolomite is slightly ferruginous. A few doubly-terminated quartz-crystals occur.

Upwards the dark limestone (No. 1), as at Pen-rhiw-du, passes into light grey amorphous limestone and sandy oolite, 20 feet thick to the south of Clogau-bâch, and followed by a remarkable bed 1 foot 6 inches thick, made up apparently of angular pieces up to 2 or 3 inches long of dark-grey limestone set in a light-grey matrix, from which they project on weathered surfaces, the whole looking much like a breccia. Under the microscope the rock is thus described by Mr. E. E. L. Dixon :—

E. 4260.—The groundmass of the dark parts is crystalline calcite, whereas that of the light part is more amorphous. It is clear that the rock is not fragmental, as the darker parts merge into the lighter and contain the same fossils, chiefly foraminifera. The difference is due to partial recrystallisation of an originally homogeneous mass, resulting in parts becoming more translucent, and thus appearing darker in the specimen. As another result of their crystalline character these parts are more durable in weathered specimens.

Mr. R. L. Sherlock identifies the foraminifera as chiefly *Endothyra bowmani*, Phillips, with *Haplophragmium* or *Nodosinella*, and probably *Trochammina*. He finds also an abundance of *Calcisphæra*, an organism of unknown affinities, and of a form suggestive of an alga, such as *Gyroporella*.

Upon this breccia-like rock rests the honeycombed sandstone, where unweathered a calcareous fine-grained grey rock, effervescing freely when treated with dilute hydrochloric acid, and leaving an insoluble residue of sand-grains. It is traceable both eastwards and westwards and is followed by the light oolite (No. 2), which passes upwards through darker sandy oolite into the dark limestone with chert (No. 3). Dark-grey sandy oolite follows, and lastly the Rottenstone Beds.

On Breast Cwm Llwyd light-grey oolite is further developed in the upper part of No. 1, but otherwise the same sequence holds good.

The River Cennen provides an opportunity for observing the following details :—

River Cennen south-east of Blaen-Cennen.

		Ft.	In.
Main Limestone (part)	Dark oolite and limestone		
	Dark amorphous fine-grained limestone ('china-stone')	1	0
	Coralline limestone	1	0
	Dark oolite and limestone (lowest bed earthy)	20	0
Lower Limestone Shales 34 Ft.	Dark olive-green shales and mudstones, with one or two limestone-bands up to 1 ft. towards top	25	0
	Olive-green and yellow gritty sandstone	6	0
	Black mudstones	3	0

Grey Grits (p. 66).

The coralline limestone here is probably on a higher horizon than the coral-bed of Clogau-bâch. The upper beds of the Main Limestone are hidden under grit-débris, but rottenstone has been dug north of Llyn-du.

At Bryniau, by the side of the cart-track ascending Banc Wern-Wgan, there is a small exposure, in the middle of the shale outcrop, of an olive-green grit indistinguishable from a grit which a little farther west lies at the base of the Lower Limestone Shales and must be supposed to be the Grey Grits (p. 66). Immediately west of the Tair Carn Fault the limestone-outcrop is concealed by grit-débris, but south of Banc Wern-Wgan and westwards towards Beddau'r Derwyddon there are numerous quarries. The higher beds of the dark limestone and oolite (No. 1) retain the light colour first developed west of the Pen-rhiw-wen Fault, and the highest bed is rubbly or breccia-like. Next follows the honeycombed sandstone, here lying about 300 feet above the base of the Main Limestone; the overlying light oolite (No. 2) is about 30 or 40 feet thick. The dark limestone with chert (No. 3) is occasionally exposed; a specimen of the chert collected at a point 150 yards south-east of Beddau'r Derwyddon has been sliced for the microscope and is thus described by Dr. G. J. Hinde :—

E. 3315.—A dark splintery chert. Under the microscope it is seen to be filled with rounded or elongate bodies very faintly shown. The elongate bodies appear to be sponge-spicules; some are six-rayed hexactinellid spicules. Some of the rounded bodies may be casts of radiolaria, but they cannot be positively identified. The chert seems to be a part of the Carboniferous Limestone now silicified—the silica probably derived from sponge spicules. A fragment of *Trochammina* is also present.

Still higher, the Rottenstone Beds have been worked below the Millstone Grit.

The limestone-inlier shown on the map at the south-west end of Tair Carn was known to Logan and is mentioned in his MS.; the uppermost beds of the limestone and the Rottenstone Beds just show through the Millstone Grit on the crest of the anticline. The evidence on the ground is meagre; but the remains of a very old limekiln (disused in Logan's time, 1836–42), with pieces of limestone among the boulders of grit close by, together with a belt of old rottenstone-workings, suffice to determine the existence of the inlier, but its limits are indefinite.

At Llygad Llwchwr the limestone-outcrop is thrown northward by a westerly downthrow and here ceases to form a bare mountain-tract. The Lower Limestone Shales are exposed in Cwrt-bryn-y-beirdd farmyard and are about 18 or 20 feet thick, and a grey oolite (probably in No. 1) has been quarried immediately south of the farm.

Sections in the dark limestone and oolite (No.1) are afforded by several quarries near Llwyn-Dewi; traces of the dark limestone with chert (No. 3) appear at Cefn-coed-uchaf, and the Rottenstone Beds crop out at the foot of the Millstone Grit scarp.

Black shales and chert-bands with wavellite are exposed in the side of a road at 100 yards east of Careg-Dwyfan Cottage and specimens of the chert were found by Dr. G. J. Hinde to contain radiolaria. Though there is little doubt that these beds belong to the Plastic Clay group (p. 75) it is just possible that they may lie a few feet higher in the Millstone Grit.

Dr. G. J. Hinde's report is as follows :—

E. 3306, 3309, 3311–3314 are of the same character—dark cherts with lighter decayed portions. They mainly consist of casts of detached sponge-spicules and casts of radiolaria, both organisms very faintly shown. The radiolaria are for the most part simple circular and oval forms, probably belonging to *Cenosphæra* and *Cenellipsis*; only the outlines bounded by matrix, as a rule, are now preserved; in some instances, however, perforations in a wall can be seen. Oval forms with radial spines are rare.

The sponge-spicules are apparently minute simple acerates, but with these four- or six-rayed spicules of hexactinellid sponges are occasionally present. It is possible that some of the needle-like spicules may be broken off radial spines of radiolaria. The greater portion of the chert is evidently a mass of minute spicules or spines of siliceous sponges, with possibly some radiolarian spines; with these are commingled some radiolarian casts, but they are, relatively, in smaller proportions than the spicules.

South of Cefn-coed-uchaf a level was driven into the Rottenstone Beds about 30 years ago in search of rottenstone; the tip is of black shale. Westward towards Llandyfan all the subdivisions of the limestone are exposed; the Lower Limestone Shales are shown in a lane south of Tan-y-cincoed (p. 62), and are about 80 feet thick. The dark limestone and oolite (No. 1) was formerly burnt and is still worked for roadstone at the Cincoed Limeworks. The honeycombed sandstone at the base of the overlying light oolite seems however to have died out for a space at Llygad Llwchwr. The light oolite itself (No. 2) is repeatedly visible, but has not been quarried; the succeeding dark limestone with chert (No. 3) is exposed west of Cefn-coed-isaf and again in a quarry a few yards north of Llandyfan Church. The Rottenstone Beds do not appear to have been worked.

At Garn-fâch there is a large quarry in what are evidently the very lowest beds of the Main Limestone; the dark impure limestone contains a marked shale-band well-exposed and covered with *Productus* and bunches of corals in position of growth. A little farther to the south-west is a still larger quarry in No. 1, now worked for roadstone only, but of especial interest in that it shows the honeycombed sandstone which here reappears.

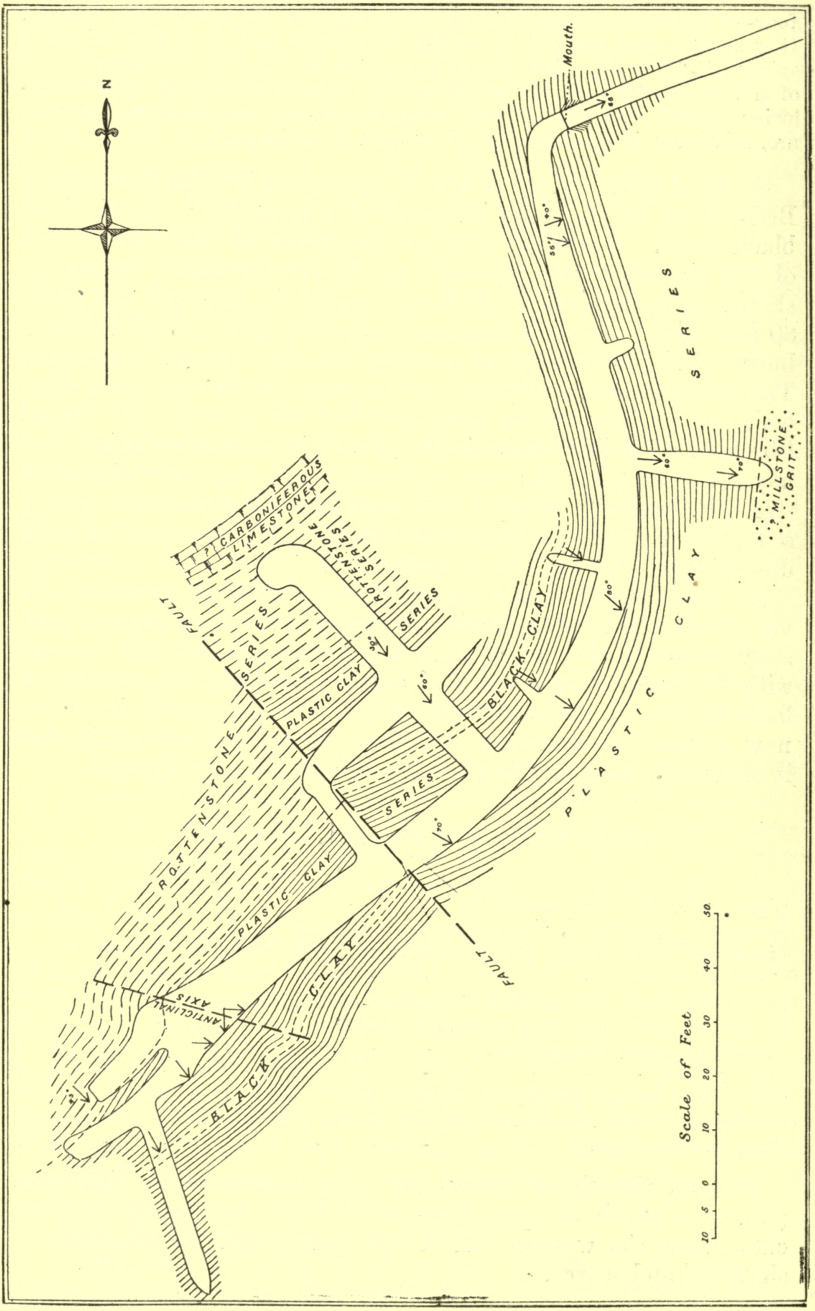
Quarry south-west of Garn-fâch, Llandyfan.

	Ft.	In.
Light oolite (No. 2 of section, p. 67)		
Sandstone, decalcified, 'honeycombed sandstone' - - - - -	12	0
Limestone, very sandy, partly decalcified, with brachiopods and a gastropod - - - - - - - - - - - - - -	3	0
Limestone, dark, fine-grained, 'china-stone' - -	1	0
Limestone, grey, very sandy, sand very fine - - - - -	1	0
Limestone, grey, fine-grained - - - - - - - - -	0	5
Clay, yellow - - - - - - - - - - - - - - -	0	5
Shale, dark-brown, sandy, becoming a grey sandstone at places, with dark carbonaceous markings, probably plant-remains - -	0	6
Clay, yellow, about - - - - - - - - - - - -	0	6

Beneath the above follows the dark faintly-oolitic limestone (No. 1) in which the quarry has been mainly excavated. A fault cuts across the western end of the quarry and the limestone is shattered and sparry.

FIG. 7.—*Plan of Underground Workings for Plastic Clay, Garnbica.*

BY T. C. CANTRILL AND H. H. THOMAS.



To the south the upper beds of the limestone are not exposed, but access is gained to the Rottenstone Beds by a level a short distance to the south-east, driven with the object of getting 'plastic clay' (p. 220). This level runs for over 250 feet into the hill, following the bedding except just at the mouth and in the side-adits. The workings reveal the whole of the beds between the top of the Main Limestone and the base of the lowest grit, and yield the following measurements :—

Garn-bica Plastic Clay Level.

		Ft.	In.
	Grits, thick-bedded, exposed for - -	3	6
Millstone Grit (Plastic Clay Beds.)	Grits, fine white - - - - - - -	2	0
	Cherts, rotten - - - - - - - -	1	0
	Clays, dark, with some hard bands - - -	4	0
	Clays, dark, with some rotten cherts in hard bands - - - - - - - -	4	0
	Cherts, rotten, yellow and grey ('plastic clay') -	2	6
	Cherts, rotten, in bands up to 6 inches thick; four or five bands of 'plastic clay' each about 6 inches thick - - - - - -	9	0
	Cherts, rotten, with 'plastic clay' bands up to 1 foot thick at base - - - - - -	10	0
	Clay, yellow - - - - - - - -	1	0
	Clay, black - - - - - - - -	1	6
	Cherts, rotten, with several 'plastic clay' bands -	17	0
Upper Limestone Shales.	Rottenstone, brown and black, with limestone cores; passing down - - - - - -	12	0
Main Limestone	Limestone, black, top only seen		

The top of the Main Limestone yielded *Chonetes laguessiana*, de Kon. [T. C. C. 1046–1048].

The rottenstone is of some commercial value, but does not appear to be of such good quality as is found farther east. The 'plastic clay' is a very fine mealy sand, of a pale yellow or white colour, containing cores of chert and apparently produced by the gradual disintegration of that rock. The last limestones to be deposited in this region contained much fine impurity, and were followed by very fine siliceous sediments, and these by the grit-beds of the Basal Grit. The fine sediments were converted into chert, but have since been disintegrated along the crop, occasional cores of black chert and the nodular form of some of the beds testifying to their former cherty character. The finest of these sands, purely siliceous and in a mealy condition, are worked for 'plastic clay.' This material is used for cementing the interior of steel-furnaces, and as it occurs only in very small quantities it is a valuable asset.

In the Plastic Clay group are several bands of black clay (probably decalcified muddy limestones), one of which, 1 foot 6 inches thick, was useful as a datum-line in constructing the plan of the workings (Fig. 7).

The dip of the beds is about S.E. at angles of 30° to 80°.

T. C. C.

The undecomposed cherts present two characters, some of them consisting of dark and white bands and closely resembling the radiolarian chert of Bishopston,* while others are dark and homogeneous.

A specimen of the banded variety (E. 4265) examined under the microscope shews the following characters :—

The bands are evidently due to the deposition of sedimentary material consisting of minute clastic grains mixed with spherical and elliptical bodies of organic origin. The latter show a shell of chalcedonic or cryptocrystalline silica, enclosing a radiating mass of chalcedonic silica. Scattered through the rock there are also minute crystals of some rhombohedral carbonate, which from its mode of occurrence and associations is assumed to be dolomite. This suggests that the rock was once slightly calcareous, and was partly or completely dolomitised, before the formation of secondary silica.

The organic material and the character of the rock recalled the radiolarian chert of Bishopston and Careg-y-Dwfan (p. 72). A specimen, therefore, was submitted to Dr. G. J. Hinde, F.R.S., who reports as follows :—

The slide [E. 4265] is crowded with minute rounded and oval spaces with, as a rule, even margins but without definite walls ; the interiors usually clear but in many there is a small central spot ; with these are cylindrical rods of approximately the same diameter as the circles. These bodies are probably spicules of siliceous sponges ; they are, however, for the most part much smaller than the spicules generally met with as fossils.

Besides these minute forms there are some bodies of pear-shaped outlines, the nature of which is unknown to me.

I cannot find any indications of radiolaria in the section. The minute circular and oval forms referred to sponge-spicules appear to me to be similar to those in the chert from Careg-y-Dwfan which I examined in 1900, and of which mention is made in the ‘Summary of Progress for 1900,’ p. 89.

Dr. Hinde also remarked on the close agreement in character of the cherts of Garn-bica and Careg-y-Dwfan and thought it probable that the Garn-bica chert contained radiolaria, though none could be found in the slide submitted to him.

Slices were cut of the dark homogeneous chert with a view to ascertaining the cause of its disintegration.

E. 4266 and 4267.—The undecomposed rock consists of chalcedonic and cryptocrystalline silica with a certain amount of clastic quartz and a few grains of zircon, and contains traces of organisms similar to those seen in E. 4265. Minute rhombs of dolomite are present as before, together with larger, almost opaque, rhombs which may be referred to partially-oxidised ferrous carbonate, or ferriferous dolomite.

In the decomposed rock the smaller rhombs are equally plentiful, but the larger crystals are absent or in skeleton, the ferruginous material having been distributed throughout the rock. There is less chalcedonic silica, and it is suggested that the disintegration is due primarily to the removal of a certain proportion of this material, as well as to the oxidation and redistribution of the ferruginous compounds.

H. H. T.

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* ‘Summary of Progress’ for 1900, p. 89 ; *see also* ‘The Country around Swansea,’ 1907, pp. 24, 25. *Mems. Geol. Surv.*

At 200 yards west of the Garn-bica level an easterly downthrow already alluded to (p. 73) produces a well-marked effect on the crop of the honeycombed sandstone. The dark limestone and oolite (No. 1) has been quarried towards Pistyll, and the honeycombed sandstone crops out, just west of the fault, a few yards north of a conspicuous dip-slope of light oolite (No. 2) containing abundant specimens of *Productus* and *Spirifer*, among which Mr. E. T. Newton identifies [T.C.C. 609–613] *Productus llangollensis*, Dav. North of Garn-bica-fâch the dark limestone with chert (No. 3) makes a prominent ridge.

At Pistyll-canol the Lower Limestone Shales are well exposed, and at the Pistyll Limeworks the dark limestone and oolite (No. 1) used to be burnt for lime, and is followed to the south by the honeycombed sandstone and light oolite. At a small pond at the foot of the Millstone Grit scarp south-east of the limeworks a trial-boring proved the plastic-clay beds.

West of Llandybie.

West of the Llandybie Valley the numerous large quarries at the Cil-yr-ychen Limeworks afford excellent sections. The Lower Limestone Shales are well exposed at the top of a sandstone quarry and in a tram line, as described on p. 63. Between the limeworks and Dinas they contain bands of decalcified earthy limestone with *Fenestella.*

The quarries afford excellent sections of the dark limestone and oolite (No. 1); buff coarsely-crystalline dolomite occurs in some of the vein-stuff. The same dark limestone forms the hill of Dinas; the overlying honeycombed sandstone comes into view on the northern slopes of the Gwenlas Valley, *e.g.*, in a recently-closed road 100 yards north-east of Cae-gwen, and the overlying light oolite (No. 2) is visible in the thickets between that place and Glan-dwr.

Though the Lower Limestone Shales form a broad dip-slope to the west of Dinas they are exposed only in Nant Gwenlas 100 yards above the Woollen Factory. West of the Dinas Fault their outcrop is too narrow to be shown on the one-inch map. The dark limestone and oolite (No. 1) was formerly got at a large quarry at Pant-y-llyn, and the same rock is now being worked by a new company at Glan-Gwenlas. The honeycombed sandstone crops out south of the Glan-Gwenlas quarry and the light oolite follows, but is poorly exposed. That some of the strata associated with the plastic clay exist here is indicated by an outcrop of soft grey sandstone under Banc Cottage, and a level was driven into the same beds by the roadside on the south side of the valley.

T. C. C.

Between Pentre-gwenlas and Heol-ddu the Lower Limestone Shales are not exposed, but between the highest beds of the Old Red Sandstone and the lowest limestone there is room for a thickness of 30 to 40 feet. Also their presence is inferred from a well-marked hollow at the base of the limestone.

From Pentre-gwenlas to the Llanelly road, south of Carmel, the limestone makes an outcrop one third of a mile wide. The increased width is largely due to the fact that the base of the limestone stands nearly 200 feet higher than the outcrop of its upper boundary, causing a long dip-slope. To the west of Carmel as the positions of the top and bottom more nearly approximate to the same level the outcrop loses half its width. From Carmel to Maes-y-bont the limestone lies in a striking hollow offering a great contrast to the more hilly country to the immediate east. Westwards from the Maes-y-bont road however it recovers itself in some degree and forms conspicuous land-marks such as the quarried stack known as Castell-y-gareg. West of Capel-Llan-Lluan the wedge-like mass of Trawsdre-isaf and Trawsdre-ganol is thrown down between two faults. A line of swallow-holes marks the junction of the Millstone Grit with the limestone near Glan-Gwenlas Farm and the River Gwenlas issues as a strong spring to the south-east of the farm. A great number of swallow-holes also occur near the base of the limestone in the hollow to the south of Carmel.

The summit of the limestone is marked by thin rottenstones and black shales, followed by rotten cherts forming the Plastic Clay group. These beds may be seen at several places along the road from Pentre-gwenlas to Garn and to the north of Banc-y-llyn near Castell-y-gareg Farm (*See* also p. 221).

H. H. T.

West of the Tumble Fault dark oolite forming the lowest part of the Main Limestone crops out in the farm-yard at Heol-ddu, and some higher beds have been quarried a little farther south. The light oolite (No. 2, p. 67) crops out in the fields half-way between Heol-ddu and Ty-llwyd, but the honeycombed sandstone seems to be absent. A quarry close to the latter house shows dark limestone overlying coarse dark oolite, both of which must be assigned to No. 3, though they contain no chert.

The dark limestone and oolite (No. 1) has been burnt at Pen-y-garn and is now worked for roadstone. The quarries are traversed by an overthrust fault which is well-exposed towards the western end of the workings and ranges eastwards. The limestone on both sides of the thrust dips about S.20° E., at 30°, and the thrust-plane dips in about the same direction at 45°. A vein of calcite in the fracture is slickensided about N. 20° E., *i.e.*, obliquely up the thrust-plane, and the limestone both above and below is laced with fine veins of calcite. The effect of the thrust is to repeat some of the outcrops and to increase the apparent thickness of the rock.

South-west of these quarries the light oolite (No. 2) has been quarried a little east of Garn-fawr and is about 30 feet thick.

At Banc-y-Mansel there are old quarries in the dark limestone and oolite (No. 1), and at Maes-Dulais a fault with westerly downthrow is exposed on the eastern side of a copse 200 yards north-west of the house. West of this place there are numerous old quarries in these beds (No. 1) and above them there lies a rubbly and clayey band 1 foot thick, followed by the light oolite (No. 2), showing that the honeycombed sandstone has disappeared or is represented by clay. The light oolite itself is about 100 feet thick, as compared with 30 feet at Garn-fawr, and is followed by about 30 feet of hard yellow marl, in places red, and containing lumps of oolite and of crinoidal limestone at or near its base. On the south side of a stream-gully 300 yards W. 14° S. of Maes-Dulais the marl rests on the rubbly upper surface of the light oolite exposed in the bed of the channel and underlies the dark limestone with chert (No. 3) which crops out in a thicket on the south. At 200 yards S. 23° W. of Maes-Dulais a swallow-hole at the foot of the Millstone Grit scarp shows the plastic-clay and rottenstone beds, which, however, have not been worked.

Thence to the edge of the map most of the limestone is exposed, including the rubbly bed at the base, and the yellow marl at the top, of the light oolite. There are signs of the plastic-clay beds in the form of soft yellow sandstone and clay in an old millrace at Ty'r-felin and in the road at Garn.

Outlier of Castell Careg Cennen.

This outlier (Fig. 10, p. 184) consists of the Lower Limestone Shales and the lower part of the Main Limestone. The shales are nowhere exposed, but presumably crop out under the limestone scree on the west and south sides of the hill. Some beds which are probably not far above the base of the Main Limestone have been quarried under the western cliffs, the section showing :—

	Ft.	In.
Dark limestone		
Dark limestone with corals in lower part - -	1	6
Black shale with corals and *Productus* - -		9
Dark limestone, seen for - - - -	10	0

The cliffs which form the southern and western edges of the plateau on which the castle stands consist of the dark limestone and oolite (No. 1, p. 67). Under the castle the cliffs are cut by several small fractures or joints. The highest beds on the outlier crop out to the north-east of the castle, where a breccia-like bed forms a dip-slope, dipping N. 20° E. at 20°, toward the fault which brings up the Senni Beds (p. 59). The breccia-like bed agrees in appearance with that which farther east, at Banc-Wern-Wgan (p. 72), and Clogau-bâch (p. 71), forms the top of the dark limestone and oolite (No. 1) and is there some 300 feet above the base of the Main Limestone. At Castell Careg Cennen there seems to be at least that thickness of limestone, so that it is probable that the honeycombed sandstone would be the bed next above the highest now present.

T. C. C.

Outlier of Bryn-yr-odyn.

A faulted outlier of limestone (Fig. 11, p. 184) occurs at Bryn-yr-odyn to the north of Maes-y-bont, and forms a mass one mile long and one sixth of a mile in greatest width. Faulted on all sides the beds are much disturbed but have a general dip in a southerly direction, ranging from 10° to 60°. The limestone is well exposed in crags and quarries, where it is seen to consist of a dark-grey oolite and, locally, to be very fossiliferous, containing abundant *Productus* and corals. The Lower Limestone Shales, while only inferred at the base of the main outcrop, are actually visible to the north in the faulted outlier at Bryn-yr-odyn. A stream-section, which is almost continuous from the Maes-y-bont road to the western end of the outlier shows, at the extreme west for 500 yards, dark-grey limestones and black shales undulating but with a general dip of from 10° to 60° in a southerly direction.

H. H. T.

CHAPTER VII.

CARBONIFEROUS ROCKS (*continued*).

MILLSTONE GRIT.

BY T. C. CANTRILL.

Introduction.

Of the three subdivisions under which the Millstone Grit has been shown in the adjoining sheet to the east (Sheet 231), the lower two maintain their distinctive characters throughout the map under description, but the Farewell Rock is not always clearly defined through having thinned out, or, more probably, having been split up, and partially replaced, by shales.

The following table shows the subdivisions in descending order with their average thickness :—

General Section of the Millstone Grit.

	Ft.
Farewell Rock.—Brown, olive-green, and greyish-white sandstone and quartzite. Thickness 0 to 450 feet - - - - - - - -	200
Shales.—Dark barren shales with occasional bands of brown, olive-green, and greyish-white sandstone and quartzite, up to 40 or 50 feet thick, specially numerous towards the base so as to form a passage down into the Basal Grit. Thickness, 250 to 850 feet - - - -	500
Basal Grit.—Grit and quartzite, pebbly in the east, but not in the west; with thick bands of dark shale, especially at the top, and thus passing by alternation into the overlying Shales. At the base in the west grit-beds alternate with thin bands of shale and the grits thus pass downwards into the Plastic Clay Beds. Plant-remains are not uncommon in the grits; some of the shales contain shells and ostracods, and rarely thin bands of black muddy limestone with fossils. Thickness, 450 to 700 feet. At the base the Plastic Clay Beds (pp. 75–77) with an average thickness of 50 feet - - - - - - - -	600

East of Llandybie.

The basal grit and conglomerate forms a bold escarpment in the Gwys-fawr Valley, and crags and dip-slopes farther south. On the downthrow side of the Twrch-fechan Fault the grit extends northwards in the long ridge of Esgair-hîr and Gareg-lâs. Here the base is often hidden by scree, but at Pen-rhiw-gôch its position is clearly defined by old rottenstone-workings. The best opportunities for examining the beds are obtained on the shoulder of Gareg-lâs, north-east of Blaen Llynfell.

The grit is very finely displayed along Tyle-garw, the precipitous south-eastern side of the Twrch Valley; and since the grit of

Gareg-lâs dips towards that of Tyle-garw, there must be a repetition by either a fault or flexure along the valley in a north-north-east direction. Confirmation of this hypothesis is found at Ffrwd-lâs, as described on page 70, and we may conclude that there is a down-fold on the north-north-west, combined probably with a thrust.

On the Twrch, half-a-mile below the mouth of the Twrch-fechan, a river-cliff on the left bank shows grit overlying a four foot bed of pyritous black shale with impersistent black limestone-bands up to six inches thick, from which Mr. E. T. Newton identifies a brachiopod as *Spirifer* ? [T. C. C. 116].

Two-thirds of a mile below the Twrch-fechan, the left bank affords the following section :—

On the River Twrch.

	Ft.	In.
Grit, thick-bedded, at top of cliff		
Shales, black and pyritous, and grits ; these form the bottom of the cliff, and pass south-westwards into grits - - - - - - - - - -	7	0
Pebbly grit, coarse, incoherent, unevenly-bedded -	2	6
Grit, worn into pot-holes - - - - - -	3	0
Grits and shales, pyritous, alternating ; in bands 2 or 3 inches thick - - - - - - - -	3	0
Grit, hard, in bed of river.		

At 170 yards lower down stream the right bank of the river shows what are probably the upper three beds of the above section; and pieces of black limestone, presumably from a band in the shales, yield *Productus* and other brachiopods. [T. C. C. 114, 115].

A little over half-a-mile farther down, and 400 yards above Ffrwd-lâs, the grits, which dip west-north-west at 80°, contain pyritous shales, and a coal-smut three inches thick, and highly ferruginous shales crop out a little lower down stream.

Upwards the grits alternate with shales and in places are finely-banded, as for example at the crossing of a brook by a bridle-road a mile north north-east of Dorwen. This rock has been sliced for the microscope and is thus described by Mr. H. H. Thomas :—

> E. 4256.—Fine-grained siliceous sandstone, composed of fragments (up to ·06 mm.) of angular quartz, muscovite, a few zircons, tourmaline, and grains of chlorite, set in a siliceous cement. The rock is microscopically bedded.

Above the alternations comes the shale-subdivision which forms the moorland of Llorfa and extends as far as Bwlch-y-ddauwynt where the shales are in places visible.

The Farewell Rock forms a narrow plateau south of Llwyn-cwnstabl, and the brown and olive-green sandstones crop out at intervals.

The grit of Cefn-y-Garn-Fadog is thrown up between two faults; the base is generally well-defined round the edge by the rottenstone-workings, but north-west of Carn Fadog there is much grit-débris on the limestone outcrop ; it has been worked for silica-sand at the head of Nant Llynfell. Much of the grit is in a friable condition, and was being worked in 1899 by the Black Mountain Co. (p. 219). By the side of the tramline 550 yards below the winding-engine a level for fireclay has been driven into black shale exposed for a thickness of 7 feet and underlying grit 12 feet thick. Every grit is probably underlain by shale, but opportunity for seeing it seldom arises. Southwards the grit-crags are cut off on the strike presumably by a fault, for shales are exposed on the silica-works incline.

The Farewell Rock, on the west side of the Twrch Valley opposite Dorwen, consists not of the usual brown and olive-green sandstone, but of white quartzite.

The Basal Grit forms the plateau of Foel Fraith, where its base is well-defined, and the overlying Shales are exposed in the Llynfell and in the Amman-fawr. The Farewell Rock in the Llynfell east of Waen-y-ddraenen consists of the usual brown sandstone.

In Gareg-lwyd the Basal Grit rises to a height of 2,026 feet; the south-east side of the mountain presents numerous rock-surfaces dipping at angles of 25° to 40°, and sections extend some distance down the Amman-fâch. The Shales are well shown at the junction of this stream with the Amman-fawr, while to the south-west the Farewell Rock makes a good escarpment.

Along the west side of the fault at Pen-rhiw-wen the débris of the Basal Grit covers much of the limestone outcrop, and has been extensively dug for sand. In a large pit working in 1900 traces of the original bedding-planes were discernible, and by their high angles (50° to 60°) show the extent of the subsidence to which their abnormal position is due. In the same pit there occurred a lenticle of coal, 1 yard thick, in a rotten condition; while in an older pit a little farther north the rotten grit contains seams of black shale and a coal-smut.

At Carn Pen-rhiw-du and Carn Pen-y-Clogau the basal crags are well preserved and a line of old pits marks the outcrop of the rottenstone beds along their foot. Llyn-y-Fignen-Felen (p. 68) occupies a hollow due to the dissolving away of the limestone-foundation from beneath the grit.

The lower beds of the Shales are visible in a rushy water-course at the head of the Garw Valley; higher beds come in down stream; the upper beds form a cliff below the Llangadock road at Craig-derlwyn. The Farewell Rock has been quarried at the eleventh milestone from Llangadock, and consists of greenish-brown sandstone with thin bands of shale, all irregularly bedded. East of the Garw a white quartzite forms a crag in the middle of the Farewell Rock outcrop.

West of the Brynamman Fault the Basal Grit forms a block-strewn feature south of Breast Cwm Llwyd, and in its lower part contains a thick band of shale exposed in Nant Oesglyn. At Carn Cennen grit-débris extends far down the limestone escarpment, but north of Llyn Du Isaf the base of the grit is defined by a crag of pebbly grit below which rottenstone has been worked.

In Cwm Pedol several sections reveal the presence of shale-beds up to 8 feet thick in the Basal Grit.

The Shales also are to be seen in Cwm Pedol, near Creigiau and Pant-y-ffynnon, and in several tributary streams flowing down from Tair Carn; here, as elsewhere, they contain thin bands of grit.

The Farewell Rock of Foel-deg-ar-bedol contains a white quartzite which makes a crag a quarter of a mile west of the carn.

To the west of the Tair Carn Fault it is possible to see that even the lowest part of the Basal Grit is almost free from pebbles; the basal crag runs to Llygad Llwchwr (p. 72), and southwards, along Gwythwch Brook, higher beds come on, and one of them has been dug for scythe-sand at 150 yards south-west of the peat-flat shown on the map. A little south of this point we reach the axis of a gentle syncline which ranges parallel with and south of the brook, and we then ascend the anticlinal ridge of Tair Carn. In doing so we can observe that the ridge coincides with and has been determined by the anticlinal structure of the grits.

The Shales at Blaen-berach dip S. 40° E. at 45°, but a few yards higher up stream, they dip S. 5° W., at 50°; the lowest beds contain a coal-smut 1 foot thick striking north-west and south-east, and vertical; there is evidently some amount of disturbance. In the rubbish from an old trial-level on the right bank of the stream at 150 yards below Blaen-berach there are traces of coal.

The Farewell Rock forms the heathery dip-slopes of Dryscol, and is laid open in the river under Bryn-pedol; it forms some inaccessible cliffs above a landslip (shown on the map) south of Creigiau, and thence gradually rises to a crag of white quartzite on the summit of Dryscol. Farther south there are sections of the highest beds among the picturesque thickets bordering the Llandilo road near Bethel Chapel.

West of the Ty-llwyd Fault some uncertainty arises as to the identity of some of the outcrops. The general effect of the fault is to narrow the anticlines and widen the synclines on its western or downthrow side. Thus the anticline of Tair Carn, though continued south-west of the fault, forms a narrower and less lofty ridge. An easterly downthrow runs through Forge Llandyfan, and this widens the anticline again, so that the Basal Grit spreads out over a considerable area about Pen-y-coed south-west of Drefâch. This tract, however, no longer consists of one anticline but of two, with a syncline between them. Finally the grit is faulted down out of sight by the Nant Garenig Fault.

North of this anticlinal tract of the Basal Grit the normal crop of the grit west of the Ty-llwyd Fault can be seen at Llygad Llwchwr, whence it runs past Llwyn Dewi, where the grit is rotten and has been dug for sand, to the bold hill of Careg-y-Dwfan.

The syncline, first recognised along the south side of Gwythwch Brook, brings in the Shales, shown along the Loughor above the mill at Forge Llandyfan; and in the road to Trapp, close to the corn-mill, they contain a 20-foot band of grit.

The Farewell Rock is probably represented by a brown sandstone which crops out in the Loughor, 50 yards below Dre-fâch Bridge.

At Thornhill a subsidiary anticline brings up the Basal Grit again in the middle of the Shales; the structure can be examined in a tributary of the Loughor 170 yards south-west of the house.

On proceeding north-westwards from these sections of the Basal Grit in the stream south-west of Thornhill, the Shales are crossed, but are not exposed; beyond them there is a long section, under boulder-clay, in soft yellow, brown, and olive-green micaceous sandstone, dipping north-west, which passes up into coarse grit containing a thin bed of highly carbonaceous shale in which a trial-pit has revealed traces of coal. These beds presumably represent the Farewell Rock, for a few yards farther down stream they pass under dark shales which are assignable to the Coal Measures (p. 112). Beyond this, to the north of the syncline, the Farewell Rock reappears and forms some cascades just above Garn-lwyd-wen.

On the south of the anticlinal tract of Basal Grit the Shales are exposed in the next brook to the west of Nant-glâs, and again farther west in Nant-y-creigle, where just above the house a band of white grit crops out.

The Farewell Rock, in the form of olive-green quartzitic sandstone 40 or 50 feet thick, and dipping N. 30° W. at 30° to 36°, is exposed at the top of Nant-glâs (a tributary of the Berach) at Garn-lwyd; it overlies the Shales, and lower down the same brook the Farewell Rock, in the form of olive-brown sandstone dipping south-east, crops out west of Aber-nant-glâs, and is seen again as light-brown quartzitic grit south-east of Nant-y-creigle, finally passing under the Coal Measures of Glanamman.

West of the Nant Garenig Fault the lowest grit crops out at Garn-bica, and its base was probably reached in one of the drifts in the Plastic Clay level described on p. 75, but a small opening 130 yards to the south-west affords a better section:—

Trial Level, Garn-bica.

	Ft.	In.
Grit, grey, top not seen - - - - - - - - -	1	0
Clay, black - - - - - - - - - - - -	0	6
Rottenstone, dark, bedded; black at top, yellow and grey below; with hard bands (decomposed cherts ?) - - - - - - - -	6	0
Shales, black, fissile, with plant-remains and *Posidoniella lævis,* Brown	3	0
Sandstone, grey, with black filamentous markings - - - -	0	2
Shales, dark, with thin sandstones - - - - - - - -	1	6
Grit, thick-bedded, yellow - - - - - - - - -	3	6
Clayey band, black - - - - - - - - - -	1	0
Grit ?		

The rottenstone contains small bodies resembling ostracods; the *Posidoniella* [T.C.C. 617] was identified by Dr. Wheelton Hind; the plant-remains consist of flattened stems up to 2 inches across.

This level shows an alternation of grit-bands, with beds which closely resemble the plastic clay beds and rottenstones described on pp. 75–77, but to judge by the relative positions of the two levels, there is little doubt that all the beds, except perhaps the lowest grit, are higher than any seen in the plastic-clay level.

Higher beds of the Basal Grit were being quarried in 1901 for silica by the Bynea Brick Company. The grit then being quarried north-west of Garn-bica Farm contained three thin partings 6 to 18 inches thick, of black, highly carbonaceous shale, or impure coal, with abundant plant-remains including *Sigillaria* [T. C. C. 627]. The beds showed signs of disturbance, possibly by the small easterly downthrow seen in the Garn-fâch limestone quarry (p. 73). More recently a silica-quarry has been opened south of Pistyll limeworks, in the Llandybie Valley.

The shales of the middle subdivision contain a 30 to 40 foot band of white grit, and are exposed at Llwyn-y-piod and Gelli-wastad.

The Farewell Rock crops out in a lane south of Garn-bica, and a little farther west in a cart-track to Llwyn-y-piod ; also it is exposed in the road a few yards south of Gelli-wastad. It is brought up again on the line of the Tair Carn anticline as a low dome on the west side of Glyn-hîr Park, where fine brown sandstone has been got.

West of Llandybie.

West of the Llandybie Valley the lower beds of the Basal Grit have been dug for sand on the south side of Nant Gwenlas, and a hollow south of Dryscol probably marks an outcrop of shale, of which, however, there are no exposures ; this is succeeded by a band of white and yellow quartzite well-exposed in an old lane leading down to Llandybie. The shales of the middle subdivision are seen on the Llandilo road a little north of the fifth milestone from Llandilo.

The Farewell Rock crosses the same road at the same milestone ; its base is formed by a band about 27 feet thick of white quartzite which makes a continuous outcrop, and has been quarried westwards towards Blaen-nant-gwyn ; this rock is overlain by olive-green and brown sandstone exposed immediately east of the Dinas Fault at the last-named farm.

West of the Dinas Fault some of the lowest beds of the Basal Grit are exposed by the side of the main road opposite Banc in a quarry which shows grit overlying 10 feet of shale, below which grit again appears. The shale contains rottenstone-bands ; both shales and rottenstone contain fish-scales and entomostraca ; and Mr. E. T. Newton identifies [T. C. C. 624–626] *Posidoniella lævis*, Brown sp., and *Cytherella.* The grit which underlies the shales is exposed at the mouth of an old level (for plastic clay or rottenstone) a few yards farther west along the road, and the shale therefore seems to lie a little above the base of the Millstone Grit, and approximately on the horizon of that at the trial-level at Garn-bica (p. 85). A little farther south there are old sand-pits in the higher beds.

The shales of the middle subdivision crop out north-east of Castell-y-graig, and are better exposed in a deep dingle south of the same place. Lower down the dingle they are followed by a grey fissile sandstone which may be taken to represent the Farewell Rock, though it is difficult to separate it from the Coal Measures above and the Millstone Grit shales below.

T. C. C.

The Basal Grit, having an estimated thickness of 600 feet, forms an elevated and rough tract of ground to the west of Pentre-gwenlas and stretches by way of Allt-y-garn to Banc-y-llyn.

Its base is marked by a thin series of shales and thin-bedded grits which upwards soon become much more massive in character. The beds have an average dip of 30° in a direction a little east of south, and are, generally speaking, well-exposed. In the neighbourhood of Garn the grits are often quite rotten, and have been dug for silica-sand.

On the southern half of the outcrop a series of narrow peat-bogs occupies a hollow running parallel to the strike of the grits, and corresponding approximately to one horizon; probably this hollow is due to shales occurring in the basal grits.

The Basal Grits are succeeded more or less abruptly by a group of black shales with thin olive-green sandstones which has a total thickness of about 300 feet. A complete section of these beds is exposed in the road and stream to the north of Glyn-yr-henllan.

The Farewell Rock, a mile to the west of Llandybie, has lost its more massive character, and has broken up into a series of olive-green sandstones and black shales in which sandstones predominate. The beds have a united thickness of about 135 feet, and pass without any lithological break upwards into the Coal Measures and downwards into the middle shales of the Millstone Grit. The series may be well seen at Glyn-yr-henllan, and some of the stronger sandstones have been quarried by the roadside 200 yards south of the Stag and Pheasant Inn.

H. H. T.

West of Llyn-Llech-Owen the Basal Grit forms a prominent escarpment; some of the rock is incoherent and has been dug for silica-sand. There are indications north of Banc-cornicyll of the presence of shale and fine grey sandstone, resembling the rotten cherts of the Plastic Clay Beds, well above its base. The higher beds of the grit are exposed along the brook which issues from the Llyn.

The shales of the middle subdivision are well exposed along the south side of the same brook, but southwards all the higher beds, which form the divide between the Llyn and the Gwendraeth-fawr Valley, are concealed by grit-débris; they are seen, however, farther east in Cwm-blwch near Castell-y-rhingyll.

The Farewell Rock overlies the shales at Cwm-blwch; it consists of light- and dark-grey quartzites with rootlets. West of this place the outcrop cannot be traced owing to the general overspread of grit-débris, and as for some distance there is no evidence of its presence it has been assumed to thin out or more probably to pass horizontally into shale.

At Foel Gastell the Basal Grit forms a bold hill on which there are several old quarries. At Capel-hîr-bâch in the middle of the limestone-outcrop a mass of grit has been let down onto the limestone and still retains its original dip so that it might be easily mistaken for an interbedded grit-band. South of the Capel there is a large sandpit, abandoned about 1899, at the foot of the grit-escarpment, in rotten grit with interbedded black shale (p. 220).

The Shales make a wide outcrop which extends southwards into the valley of the Gwendraeth-fawr, but the ground is largely overspread with grit-débris and except in a cart-track east of Morfa-melyn there are no sections. At Morfa-melyn there is a quarry in a band of fine grey sandstone which can be traced eastwards to the Tumble Fault.

The Farewell Rock reappears as a sandstone west of the fault, and occasional exposures constitute the evidence for the continuous outcrop shown on the map. The first lies north of Parc-Dai Bridge, where there is a quarry in fine greenish-grey sandstone. A similar rock appears in a dingle north of Llwyn-y-brain and in another dingle 250 yards west of the same farm. It reappears in a steep gully at Cwm-mawr Lodge east of Tre-fâch.

At Banc-y-Mansel the westerly downthrow which is visible in the limestone (p. 79) can be traced southwards across part of the Millstone Grit, but not so far as Tre-fâch. West of it the Basal Grit makes a bold feature south of Maes-Dulais near Banc-y-Mansel and crops out repeatedly along the south bank of the Dulais west of Maes-y-coed. The stream closely follows the base of the overlying Shales, of which there are excellent sections in the right bank north of Wern, especially at an old trial-drift, made presumably in search of ironstone or coal. A quartzite which forms a bold crag a little to the south-east, affords an example of the recurrence of grit in the Shales. South of Wern a dark olive-green and brown quartzitic sandstone in the Shales forms a long dip-slope, and a brown sandstone with traces of plants, referable to the Farewell Rock, has been quarried 300 yards north of Clôs-isaf.

West of the Dynant or Clôs-isaf Fault the Basal Grit runs as a bold escarpment with numerous crags and bare dip-slopes past Tan-y-banc, and leaves the map at Garn. The grit is generally soft and has been dug for sand. The Shales follow, with a marked bed of grit not far above the base and well-exposed at Pant-gwyn. Two other grit-bands are present still higher in the Shales, but they soon disappear westwards; the lower is a hard brown and olive-green quartzitic sandstone, and has been quarried along a picturesque escarpment south of Gwag-bola-buwch; from one of the quarries stone has recently been got for building an adjacent school. The shales overlying this are seen in a valley a little farther south and have been tried for ironstone or coal. The upper grit-band, a very fine-grained white and yellow quartzite, is well exposed at Pen-y-lan-fawr, and the shales overlying it in a lane north-west of Coed-moelon.

The Farewell Rock forms a long dip-slope at Banc-tai-newydd and is quarried at Cilau-uchaf, north of Pontyberem.

T. C. C.

CHAPTER VIII.

CARBONIFEROUS ROCKS (*continued*).

COAL MEASURES.

Introduction.

The threefold division of the Coal-measures which proved suitable in Monmouthshire and through a large part of Glamorganshire has been adopted in the part of the Coal-field included in Sheet 230. The difficulty, however, of identifying the seams which were selected as convenient limits to those divisions increases westwards, and their precise correlation in the eastern and western ends of the coal-field is, and always will be, partly a matter of opinion. For the purposes of the map the following classification has been adopted :—

Upper Coal Series ; at its base the seam known in various parts as the Primrose, the Wernffraith, the Swansea Four-feet, the Box Big or the Llanelly Six-feet.

Pennant Series ; at its base the seam known as the Ynysarwed and Garn Swllt to the east of the Loughor, but not named further west. This series could well be subdivided near Neath and Swansea into an Upper and Lower Pennant, taking the Hughes group of seams as separating the two, but the subdivision would be impracticable both to the north and west.

Lower Coal Series ; including at its top some massive sandstones (the Llynfi Rock) 900 to 1,200 feet thick, which form a passage up into the Pennant ; at its base the lowest known seam, or the top of the Farewell Rock.

The Upper Coal Series occupies small areas along the southern margin of the map. The upper part of the Pennant Series, which has yielded the bulk of the coal got near Swansea and Llanelly, occupies the southern part of the map and is succeeded northwards by the unproductive lower part of the Pennant. The Lower Coal Series crosses the centre of the map from east to west, and contains the principal seams worked in the region under description. The part of the North Crop thus included extends from Ystradgynlais to Pontyberem, and constitutes an important section of the anthracitic region.

The composition of the coals will be discussed in another volume, but it may be stated here that the seams in the Lower Series are anthracitic, though those in the upper part of that series are less completely anthracitised than those in the lower part. The seams in the lower part of the Pennant are still less anthracitised and may be described as dry steam-coals, and lastly the higher seams range from steam-coals to bituminous. The change from anthracitic to bituminous coal takes place (1) vertically, every seam, with curiously few exceptions, being more bituminous than the one below it ; and (2) horizontally, every seam becoming more bituminous towards the south, for the same seams which are anthracitic at their north crop are known to be bituminous on the south side of the basin. The determination of the rate of the change therefore becomes important in respect to the character of the deep-seated coal to be anticipated under the central parts of the Coal-field. The question is still under investigation, but reference may be made to evidence laid before the Royal Commission on Coal Supplies[¶] by Mr. John Roberts, which throws much light on the subject and on the methods employed in making the forecast.

The part of the North Crop which falls within the limits of the map under description has been subjected to great disturbance. Not only are the seams over-folded and over-thrust, but the whole mass of sedimentary material has undergone deformation. The few shaft-sections which are obtainable do not therefore give the normal thicknesses between the seams, and we have to rely upon estimates obtained by averaging data collected over a considerable area. The following table is based, so far as regards the strata above the Stwrain Seam, upon measurements made by levelling down the hill-sides, and, so far as regards the strata below that seam, upon the consideration of a number of workings extending from Ystradgynlais to Gwaun-cae-gurwen. The column for the Amman Valley has been drawn up by Mr. Cantrill.

Principal Seams of the Lower Coal Series.—East of the Loughor.

	Ystradgynlais Neighbourhood.		Amman Valley.[‖]	
	Thickness in feet and inches.	Distance below Ynysarwed Vein in yards	Thickness in feet and inches.	Distance below supposed Ynysarwed Vein in yards.
Ynysarwed Vein	—	0	2 ft. 6 in. –3 ft.	0
Pantrhydydwr Vein	0–2·0	—		—
Pinchin Vein, Upper	2·2	45	—	—
Pinchin Vein, Lower	2·4[*]	50[†]	—	—
Welsh Vein	—	—	—	—
Red Vein	2·9–3·6	285[‡]	3 ft.–4 ft. 6 in.	370
Blackband ironstone	1·8[*]	402[†]	—	—
Soap Vein	1·0	515	—	—
Penny Pieces Vein	1·0[*]	523[†]	—	—
Stwrain Vein	2·0[*]	533[§]	3 ft.	620

[¶] 'Second Report,' vol. ii, 1904, pp. 302–317, and vol. iii, 1904, pl. xxi, xxii, xxiii.

[*] According to Mr. Morgan W. Davies, in 'Second Report of the Royal Commission on Coal Supplies,' vol. iii, 1904, pl. xxiv.

[†] From measurements made in Farteg Hill.

[‡] From a measurement made at Ynysygeinon Junction.

[§] Distance below the Penny Pieces Vein as given by Mr. Morgan W. Davies, *op. cit.*

[‖] Based on a number of records and observations and including the district extending from Cwm Llynfell to Cwm Amman.

Principal Seams of the Lower Coal Series.—East of the Loughor.—cont.

	Ystradgynlais Neighbourhood.		Amman Valley.‖	
	Thickness in feet and inches.	Distance below Ynysarwed Vein in yards.	Thickness in feet and inches.	Distance below supposed Ynysarwed Vein in yards.
Upper Four-feet or White Vein	3·0*	544§	2 ft.	631
Upper Black Vein	2·10*	552§	2 ft. 10 in.	639
Pencraig, Little, or Four-feet Vein	3·6–2·0	574§	2 ft. 8 in.	662
Harnlo Vein	2·9*	594§	2 ft.	679
Big or Stanllyd Vein	9·0–5·9	618§	5 ft.	701
Lower Black Vein	—	—	2 ft. 6 in.	713
Brass Vein	3·1*	638§	3 ft. 6 in.	736
Trigloin Vein	—	657	3 ft.	755
Brynlloi or Little Vein	—	—	3 ft.	763
Little Brass Vein	—	—	2 ft.	775
Middle Vein	—	—	2 ft. 8 in.	784
Lower Vein	—	—	3 ft.	801
Bryn Vein	—	—	2 ft. 4 in.	922
Astell Vein	—	—	1 ft. 6 in.	962

For reference notes see page 91.

The coals of the Gwendraeth Valley cannot be correlated individually with those of the Amman Valley, but it is not unlikely that the Gwendraeth Stanllyd is identical with the Amman Stanllyd or Big, and that the Carway is not far from agreeing in position with the Red Vein (p. 134). The following list of the principal seams of the Lower Coal Series of the Pontyberem and Pont Yates neighbourhood and their approximate positions has been drawn up by Messrs. Cantrill and Dixon:—

Principal Seams of the Lower Coal Series—Gwendraeth Valley.

	Thickness in feet and inches.		Distance below supposed Ynysarwed Vein in yards.
Brondini (supposed Ynysarwed) Vein	3	0	0
Carway-fawr Vein	3	6	472*
Big Vein	7	6	675
Green Vein	2	9	684
Ddugaled Vein	3	0	715
Hwch Vein	1	0	734
Stanllyd Vein	4	0	738
Gras-uchaf Vein	3	0	751
Gras-isaf Vein	?		761
Brasslyd Vein	2	8	792
Gwendraeth Vein	3	0	821
Lower Triquart Vein	2	0	852
Little Vein	1	6	887
Lower Pumpquart Vein	3	9	898†
Rhas-fâch Vein	1	6	965‡

A. S.

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* The base of the cockshot rock is 300 yards below the Brondini Vein.

† The top of the Farewell Rock is 80 yards below the Lower Pumpquart Vein.

‡ This seam is not known to exist in Sheet 230.

Microscopic Characters.

The following are the microscopical characters of some typical Coal Measure sandstones:—

One or two bands of quartzitic sandstone presenting the characters of 'cockshot' occur in the Lower Coal Series, about 300 or 350 yards below the supposed No. 2 Rhondda Vein.

One of them which crops in the Mynydd Mawr Railway at Cwm-blawd, south-east of Pontyberem, was found by Mr. Thomas to present the following characters under the microscope:—

> E. 4269.—Loosely-packed sandstone, consisting of angular quartz-grains set in a crypto-crystalline ground-mass of secondary silica. Some crystals of brown and blue tourmaline are present. There are some black carbonaceous particles parallel to the bedding. *Quartzitic sandstone.*

Another 'cockshot' [E. 4268], from a quarry 180 yards east of Pen-yr-heol, a mile south-west of Pant-y-ffynnon, contains fragments of coal, apparently anthracite.

T. C. C.

The following description by Dr. Flett of a microscope-slide (E. 3585) of the sandstone from a quarry in the Llynfi Rock at Dyffryn (p. 133) demonstrates the resemblance of the rock to Pennant sandstones as described below.

> E. 3585.—Grey, gritty sandstone with quartz, a fair amount of weathered felspar, fragments of slate, and pieces of sheared quartzite. The slate or shale is abundant, and probably gives the rock its dark colour. There are grits both sheared and unsheared, and decomposed rocks which may be of volcanic origin. Many of the quartz-fragments show cataclastic structures. The other ingredients are muscovite (both original and secondary), chlorite, iron-oxides, and zircon.

The sandstones which form the greater part of the Pennant Series near Llanedy and Llannon have the same general characters in this part as in the rest of the coal-field. They are generally open-grained, but in places, as for instance Gwal-yr-hwch (p. 155), have been cemented by silica into a compact rock closely resembling the cockshot-rock mentioned above. A constant feature of typical Pennant sandstones is the abundance in them of opaque white grains which microscopic examination proves to be felspar more or less kaolinised, or, probably quite as frequently, sheared quartzite and other quartzose rocks, generally with cataclastic structures. Pieces of dark, shaly-looking rocks, and coal-fragments having the appearance of anthracite are also common. The following notes by Dr. Flett are based on the microscopic examination of specimens E. 3586–3593, from near Llanedy.

> All contain pieces of quartz, subangular or rounded, sometimes 'granitic,' but often sheared and showing cataclastic structures. With these occurs quartzite often sheared and dragged out, but in other cases comparatively little altered. These quartzites are frequently fine-grained and filled with impurities. Felspar is common also, usually much weathered, and includes both orthoclase and plagioclase. But the special feature of the series is the abundance of pieces of shale or slate in small, dark, angular splinters, and the grey colour of the rock is apparently due to their presence. They are softer than the

> quartz, which has often been pressed into them and indents them. Much-decomposed fragments which may have been derived from igneous rocks are often to be observed. White mica in worn scales is common and usually visible on the bedding-planes. The other constituents are biotite, chlorite, zircon, iron-oxides, and rarely tourmaline.

Another rock exposed by a stream 410 yards south of Gelli-Lywarch (E. 4271) is conglomeratic and, besides abundant pieces of cataclastic quartz-rocks, contains several of a brown rock, which is most probably a spherulitic rhyolite.

E. E. L. D.

The rock cropping out in the Pennant Series at Fforest near Pontardulais, and referred to on p. 166 as resembling 'cockshot,' is thus described by Dr. Flett :—

> E. 3630.—A coarse quartzose sandstone, consisting mostly of grains of quartz and quartzite with a small amount of felspar and fragments which may be derived from acid igneous rocks. Iron-oxides and zircons are accessories. The rock is firmly cemented together by a fine siliceous cement.

Fossils (*not including plants*).

The following specimens, except those from the Lower Pumpquart Vein, have been collected from the Coal Measures by the Survey :—

Localities.

1. Ynys-ci Colliery, ¾ mile E.S.E. of Ystalyfera Station. [J.P. 1493–6.]*
2. Pwll-bâch Colliery, Ystalyfera. [J.P. 1517.]
3. 100 yards N.W. of Post Office, Pen-rhiw-fawr. [J.P. 1528–9.]
4. Brook Colliery, 1¾ miles S.E. of Brynamman Station. [J.P. 1537–9, 1541–2.]
5. Cwm Gors Colliery, 1¾ miles S.S.W. of Brynamman. [J.P. 1556–7.]
6. Cawdor Colliery, 1⅛ miles S.S.E. of Garnant Station. [J.P. 1572, 4, 5.]
7. Glyn-môch Colliery (disused), 1½ miles W. of Garnant. [J.P. 1603.]
8. 200 yards S.W. of Glyn-côch Farm, Cwm Clydach. [J.P. 1455–6.]
9. Graig Cwm Level No. 2, 500 yards N. of Glyn-côch Farm, Cwm Clydach. [J.P. 1479–81.]
10. ¼ mile E.N.E. of Pen-y-banc Farm, Cwm Clydach. [J.P. 1314.]
11. Clydach Merthyr Colliery, 500 yards W.S.W. of Pen-y-banc Farm, Cwm Clydach. [J.P. 1355–8, 1393–4, 1405, 1407, 1409.]
12. Levels, 1¼ miles S.W. of Pontardawe Church. [J.P. 1301, 1308–10.]
13. New Crosshands Colliery.
14. Stream, 300 yards E. 15° S. of Dyffryn, Llanedy (p. 133). [E.D. 231.]

Graigola Vein.

Insect-wings, 11, 12.
Euphoberia armigera, *M. & W.*, 11.
Eophrynus sp., 8.
Eurypterid, 9.
Prestwichia *cf.* rotundata, *H. Woodw.*, 11.
Anthracomya pumila, *Salt.*, 9.
Carbonicola aquilina ? *J. de C. Sow.* sp., 12.
Carbonicola ?, 9, 10.
Carbonicola sp., 11.

Below No. 2 Rhondda Vein.

Anthracomya sp., 14.

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* The numbers in brackets indicate the numbers of the fossils on the collector's list as explained on p. 14.

Red Vein.

Strepsodus (scale), 4.
Estheria, 1, 2.
Beyrichia arcuata, *Bean,* 6.
Gasteropod, 4.
Anthracomya ?, 3.
Carbonicola acuta, *J. Sow.* sp., 7.
,, aquilina ? *J. de C. Sow.* sp., 5.
Myalina compressa, *Hind,* 3.[*]
Naiadites, 4, 6.

Lower Pumpquart Vein.[†]

Carbonicola acuta ? *J. Sow.* sp., 13.
,, aquilina ? *J. de C. Sow.* sp., 13.
Carbonicola ovalis ? *Martin* sp., 13.

Lower Coal Series.

The Tawe Valley and Cwm Twrch.

The faults and crops of the seams in the part of the Tawe Valley lying above Ystradgynlais are described in Part V of the Geology of the South Wales Coal Field.[‡] It was there shown that at least two large faults with downthrows to the north pass down the vale in a south-westerly direction, forming part of the complicated disturbance which traverses Cribarth. The effect of these faults is to repeat the outcrops of some of the seams. Thus the Four-feet Seam, rising to the north-west, comes to the surface just below the Ystradgynlais Colliery. Further to the north-west it crops out again under the village, having been thrown down by the first of the faults alluded to. Further on again, on the north side of the canal and in the Giedd, it crops out a third time, having been thrown down by the second fault alluded to.

The first of these faults, commonly known as the Cwm-ddu fault, ranges for Ystrad-fawr, but there passes under the alluvial flat, where it has not been proved. The second was reached in the Four-feet workings from Giedd, about 150 yards south-east of the Tawe at Ystradgynlais,[§] but has not been proved further to the south-west.

These two faults, if they keep their course, should pass down the Tawe Valley by Ystalyfera, but there is no evidence there of a northerly downthrow. On the contrary the veins are at a lower level on the south-east side than they are on the north-west side of the valley, and by just so many feet as may be accounted for by the south-easterly dip.

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[*] This determination has been confirmed by Dr. Wheelton Hind. *Myalina* is a marine form. No marine fossils have hitherto been recorded in South Wales at so high a level in the Coal Measures. Those previously known in the Lower Coal Series will be found recorded in 'The Country around Abergavenny,' 1900, pp. 86, 87, *Mem. Geol. Surv.*

[†] In the collection of Mr. D. F. Davies of the New Crosshands Colliery, and identified by Mr. E. T. Newton.

[‡] A. Strahan in 'The Country around Merthyr Tydfil,' 1904, pp. 71–75, 95–97, *Mem. Geol. Surv.*

[§] For the information concerning this fault I am indebted to Mr. E. R. Fisher.

On the south side of the Cwm-ddu Fault the Red, Four-feet or Little, Big, and Brass Veins have been worked of late years, while in old days a Black Band which lies between the Red and Four-feet Veins was in great request. The Brass Vein crops out between Ystrad-fawr and Ystrad-isaf and the Four-feet occupies its proper position further south. The Four-feet Vein, however, which has generally been the most valuable coal of the district, was traversed by a fault ranging north-westwards and forming the north-eastern limit of the Wern-plemys workings. Though not shifting the seams more than 10 yards the fault is said to have changed the character of the coals, in support of which statement the following measurements were adduced. To the north-east of the fault the Four-feet Vein was 3 feet 6 inches thick, to the south-west of it it was 2 feet thick and became known as the Little Vein. To the north-east of it the Nine-feet Vein had a thickness of 9 feet, to the south-west of it the thickness was 6 feet and the seam was known as the Big Vein.‡ Apart from the fact that it coincides in position with this change in the seams, the fault appears to be of little consequence. A more important disturbance runs almost due north under the entrance to the Wern-plemys Drift. It was proved in the Blackband workings to be a downthrow west of about 50 yards, and is said to have had an unusually low hade. This fault has not been proved elsewhere, but ranges down Nant-y-Rhôs.

To the west of the last-mentioned fault the crops of the Red Vein and Blackband are easily identified. The former was being worked in 1899 at the Farteg Colliery with a thickness of 3 feet 3 inches to 3 feet 6 inches. Higher up the hillside the Welsh, Pinchin and Ynysarwed Veins are indicated by a few old crop-workings, but seem to have been unremunerative. The Pinchin Vein is said to have consisted of 2 feet of coal above and 3 feet below, with 1 foot of rubbish between.

In the bank of the river under Pen-rhiw-farteg a coal 1 foot thick is identified as the Penny Pieces Vein. The crop is 380 feet below that of the Red Vein, and 500 yards north of it in the direction of full rise. Assuming the rise to amount to 8 inches to the yard, these figures indicate a distance of about 238 yards between the veins. The Penny Pieces lie about 50 yards above the Four-feet Vein, from which we obtain the measurement of 288 yards between the Red and Four-feet Veins. The distance is generally reckoned at about 300 yards along this part of the North Crop.

The Red Vein is being worked also at the Ynys-y-geinon (Ynys-ci) Colliery, 1500 yards N.E. of the Ynys-y-geinon Junction. The level enters the seam between two faults, both downthrows to the west. The eastern fault has a throw of 40 yards near the crop of the vein, but of only 8 yards a quarter of a mile southwards; the western fault has a throw of 60 yards and can be traced across the mountain to Blaen-nant-Meirig. A third fault with a downthrow of 20 yards to the west, and ranging a little east of north, is visible in the crags of Daren Wyddon. These faults, with an aggregate downthrow of about 100 yards, are believed to pass under Gyrnos, and to cross the Twrch about 200 yards below Melin Palleg, where the Lower Vein of the north side has been brought into undue proximity with the Brass Vein of the south side of the valley (p. 99).

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‡ This information was furnished by Mr. E. R. Fisher.

To the west of these faults and of the conspicuous landslip of Daren Wyddon, a coal 15 inches thick is visible in the Daren-fâch and another of the same thickness in a watercourse south of Daren-fâch. These two, which perhaps represent the Welsh and Pinchin Veins, can be traced along much of the hill-side to Cwm Clic, where the upper one is shown to a thickness of 2 feet in a trial-level. What appears to be a third seam is shown in a clay-pit as below :—

Cwm Clic Clay-pit.

	Ft.	In.
Sandstone	—	—
Coal	0	6
Clay	20	0
Dirty Vein, with partings	2	6
Clay	7	0
Rock	—	—

The Red Vein was sunk to at Ynys-y-geinon Junction at a depth of 148 yards, and at the Crimea Pit on the opposite of the valley, almost in the direction of the full rise of the strata, it was reached at 60 yards, the distance between the shafts being 450 yards. The Ynysarwed Vein crops at 300 feet above the Ynys-y-geinon pit, and making allowance for a dip of 6 inches to the yard we get 285 yards as the distance between it and the Red Vein.

Section of Ynys-y-geinon Pit.

Communicated by Mr. E. R. Fisher.

Dip 6 inches to the yard (9°).

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Blue clay	55	0	55	0
Rock	55	0	110	0
Clift	7	0	117	0
Coal (supposed to be the lower of the two veins in the cutting at the junction)	0	10	117	10
Rock	72	2	190	0
Coal	0	10	190	10
Clift	144	2	335	0
Coal	2	0	337	0
Rock	58	0	395	0
Coal	0	5	395	5
Rock	45	7	441	0
Clift	4	0	445	0
Red Vein	3	0	448	0

The Red Vein a few years ago was unsaleable, but now obtains a market. It is used in the Kensington and Brompton Electric Works, where the fires are banked up during a large part of the twenty-four hours, but where a full head of steam is required at short notice near midnight. The coal is a bastard anthracite, *i.e.*, it contains too large a proportion of bituminous matter for an anthracite, but too small a proportion for a steam-coal.

Half a mile further south a pit has recently proved at 95 yards depth a seam of 3 feet 7 inches thickness, which was considered to be the Red Vein. Judged by the direction of level-course the depth to the Red Vein should have been rather greater than at Ynys-y-geinon Junction.

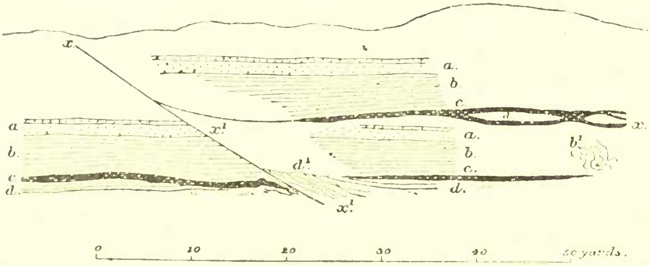
On the west side of this part of the Tawe all the veins from the Pinchin downwards have been, or are being worked. The Pinchin crops at the foot of the crag from which the great landslip of Craig-arw has slid. The Old Mountain Level above Godre'r-graig and others at the north end of the hill show :—

	Ft.	In.
Shale	–	–
Coal 6 inches to	1	9
Shale 1 ft. 4 in. to	2	0
Coal	2	6

Lower down the hill there are several paving-quarries in an evenly-bedded sandstone, and below this again there is a coal with a sandstone-roof which may represent the Welsh Vein. The Red or Pwll-bâch Vein is being worked at a level in the main street of Ystalyfera, and was formerly got by the Cyfyng Level at the Ystalyfera Works. A fault with a downthrow west passing under the works and Allt-y-grûg Farm, cuts off the vein before it crops, but at that farm and again at Cilfach-yr-haidd the coal comes to the surface with a thickness of 3 feet 11 inches. South-west of the latter place it appears to have been unprofitable.

FIG. 8.—*Overthrusting in Coal Measures in Gyrnos Patch.*

BY A. STRAHAN.



a. Sandstone. *b.* Shale. *c.* Coal. *d.* Shale.

This group of strata is three times repeated.

b^1 Shale above the coal contorted.

d^1 Shale below ,, ,,

x to *x*. Principal thrust. x^1 to x^1. Minor thrust.

The Gyrnos Patches in the mine-ground associated with the Black, Soap, and Little Veins are now abandoned. The Black Vein is conspicuous in the top of the great excavation. In following the crop for some 400 yards several small overthrusts will be noticed, by each of which the coal is repeated for a few feet or yards; but at the north end of the excavation the overthrusting takes place on a larger scale as illustrated in the preceding sketch.

In other parts of the patch small overthrusts can be detected, and in some cases movement along bedding-planes, especially along thin coal-seams, is evidenced by a layer of coal, or coal and shale, with an obvious schistose structure.

A coal 2 feet 3 inches thick called the Soap Vein, but not apparently the Soap Vein of the table on p. 91, crops out about 8 yards below the Black Vein, and a small outlier of one of the seams has been left in a conspicuous position in the middle of the patch. The Little Vein crops out along the tramway to the old Gilwen Colliery. The coals below are being opened out by drift at Tir-bâch, but both Big and Brass Veins have been worked near Allt-y-grûg Farm, and the fault mentioned above proved, its effect being to bring the Brass Vein and White Vein workings on its eastern side against Big Vein and Black Vein workings on the western side. In the bank of the Twrch, opposite Bethel Chapel, Cwm Twrch, the Middle Vein is said to crop, and an old level on the opposite (north-eastern) bank was on the Lower Vein. Between these crops and that of the Little Vein the Gyrnos Fault alluded to on p. 97 is supposed to run. Presumably the Big and Brass Veins are cut off by this fault and fail to reach the surface, but a few yards further north the latter is visible along the south bank and in the bed of the river for more than a quarter of a mile.

At Gilwen Colliery the Little, Big and Brass Vein Coals were worked, and in former days the Blackband ironstone. A fault with a downthrow to the south-east was proved to range down the valley, while disturbed ground was encountered in all the veins mentioned under the bottom of the valley about 800 yards south-west of the Gilwen Drift. Thence southwards the ground remains unproved. The Black and White Seams crop out in an old patch 450 yards north-west of the drift and run thence round the south side of Mynydd-bâch; the Little or Four-feet Seam was worked in connection with some noted ironstone and crops out in the top of old patches on the north-east side of Mynydd-bâch, while the Big Vein follows a fairly regular course along the right bank of the river below.

We now reach a part of Cwm Twrch in which folding and overthrusting become extraordinarily abundant. Speaking generally, the folds seem to fall into the N.E.-S.W. system, but amid the multitude of flexures it is difficult to pick out the principal lines of disturbance, and some at any rate may be connected with the larger north-and-south faults, such as that at Gyrnos. The belt of ground most subject to disturbance, however, appears to lie on the north side of the Ystradgynlais Fault described on p. 95, and to extend in a west-south-west direction across the Giedd and the Gwys, involving the lower part of Cwm Twrch. In the Giedd the Four-feet Seam crops about 60 yards above the canal-bridge, and further up the Harnlo, Big, and Brass Veins are said to have been seen in their proper respective position, all dipping south at 20° to 30° in the old patch on the north bank of the canal. But 900 yards south-west of the bridge, the measures were in complete confusion and not identifiable, except that some of the Four-feet Seam was thought to have been recognised. Ascending the Giedd we see measures associated with some of the lower seams, dipping southwards and south-eastwards at 30° to 40°, but near Hen-glyn we pass over a sharp anticline and get a north-westerly dip of 30° to 45°. This anticline passes up Nant-y-Cyw, and at the junction of that stream with the Giedd is faulted against strata dipping normally southwards. In the other direction it crosses the Gwys at Tir-y-gôf, and keeps on the north side of that stream to Cwm Trwch. So far as regards the upper Giedd and upper Gwys, the anticline is succeeded by ground with a gentle southerly dip. Measuring from it to the Cwm-ddu Fault we get a breadth of about 1⅓ mile for the whole belt of disturbance.

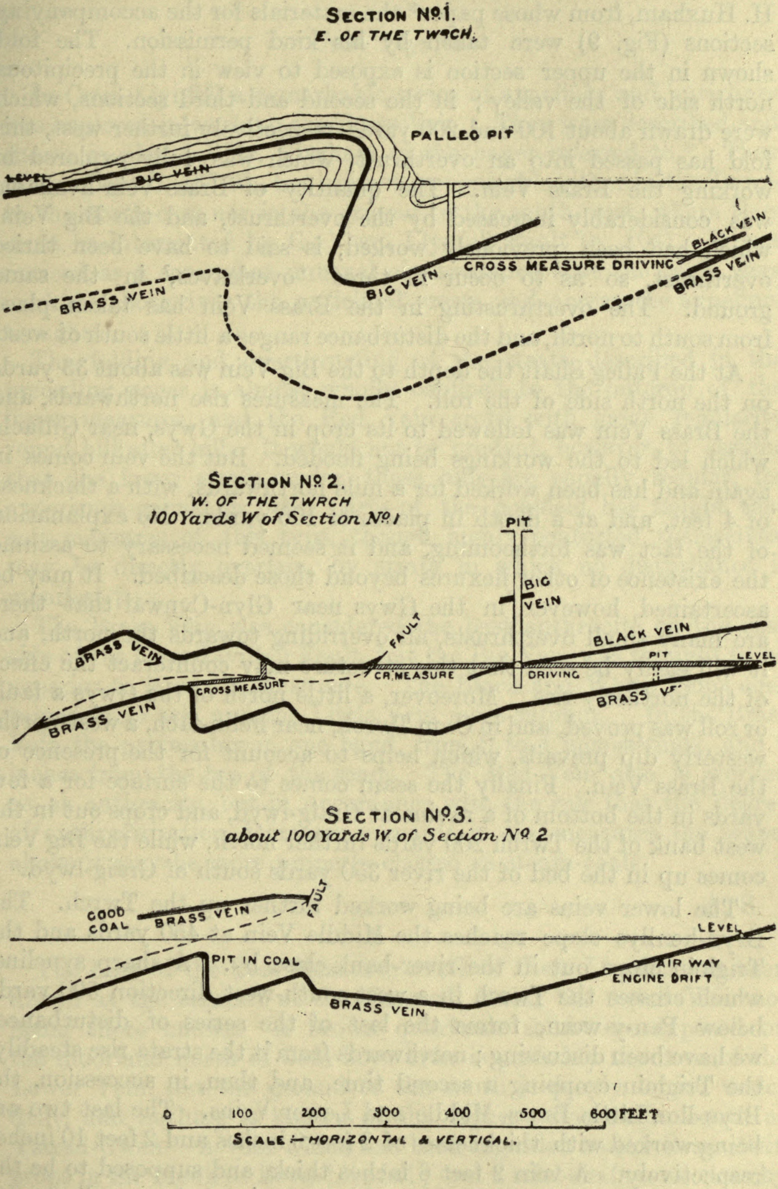
Of the lowermost veins on either side of this anticline nothing certain is known. The Cnapiog, corresponding presumably to the Lower Seam, is supposed to crop out between Pen-rhiw and Cwm-giedd on its south side, and the Middle Vein is said to have been seen at Bryn-y-graenon on its north side.

In the Cwm Phil Colliery and patch the Trigloin and Bryn-lloi Veins have been worked together with mine. The Lower Vein has been proved in a level north-east of Bethel Chapel, and the Middle Vein is said to have been visible in the west bank of the river close by. An anticline runs through the patch and across the river in a west-south-west direction.

The lower part of a ravine at Melin Palleg traverses a series of sharp anticlines all ranging a little south of west, and a trial by the side of the road, 260 yards north-west of Melin Palleg, proved the Trigloin Seam, the Brass Vein which crops in the bed of the river being 'out.' The Brass Vein, however, takes the ground again a few yards to the north of these folds, and has been much worked under the ground between the Twrch and a north-and-south fault about to be described.

The fault in question is a downthrow west, and has been reached in the working of the Brass Vein from old Bryn-henllys colliery, where some trial-pits were put down to the east of it, which proved that it threw out that vein. It is visible in the Twrch, 300 yards above Pen-y-wern, and thence for some miles northwards follows the course described on page 175. To the south it was touched about 2 chains west of Glyn-Cynwal-uchaf, and may be assumed to trend a little eastwards from that farm to the point to which the Gyrnos Fault was traced on p. 99.

FIG. 9.—*Sections showing the passage of the Palleg Monocline into the Bryn Morgan Overthrust.*



SECTION No. 1.
E. OF THE TWRCH.

SECTION No. 2.
W. OF THE TWRCH
100 Yards W of Section No. 1

SECTION No. 3.
about 100 Yards W. of Section No. 2

SCALE:—*HORIZONTAL & VERTICAL.*

In the workings of the Big and Brass Veins to the west of this fault some remarkable structures were found. One of the most instructive was worked out in detail at the Palleg Colliery by Mr. H. Huxham, from whose paper* the materials for the accompanying sections (Fig. 9) were taken by his kind permission. The fold shown in the upper section is exposed to view in the precipitous north side of the valley; in the second and third sections, which were drawn about 100 and 200 yards respectively further west, this fold has passed into an overthrust, which was fully explored in working the Brass Vein. The quantity of Brass Vein available was considerably increased by the overthrust, and the Big Vein, which had been previously worked, is said to have been thrice overthrust, so as to occur in three 'overleaves,' in the same ground. The overthrusting in the Brass Vein has taken place from south to north, and the disturbance ranges a little south of west.

At the Palleg Shaft the depth to the Big Vein was about 33 yards on the north side of the roll. The measures rise northwards, and the Brass Vein was followed to its crop in the Gwys, near Gilfach, which led to the workings being flooded. But the vein comes in again and has been worked for a mile northwards, with a thickness of 4 feet, and at a depth in places of 100 yards. No explanation of the fact was forthcoming, and it seemed necessary to assume the existence of other flexures beyond those described. It may be ascertained, however, in the Gwys near Glyn-Cynwal that there are many small overthrusts, all overriding towards the north, and it will easily be seen that this structure may counteract the effect of the northerly rise. Moreover, a little north of the Gwys a fault or roll was proved, and in Cwm Twrch, near Felin-fâch, a west-north-westerly dip prevails, which helps to account for the presence of the Brass Vein. Finally the seam comes to the surface for a few yards in the bottom of a ravine at Graig-lwyd, and crops out in the west bank of the Twrch 200 yards further north, while the Big Vein comes up in the bed of the river 350 yards south of Graig-lwyd.

The lower veins are being worked further up the Twrch. The Bryn-henllys slope reaches the Middle Vein at 450 yards and the Trigloin crops out in the river-bank close by. A sharp syncline, which crosses the Twrch in a west-south-west direction 500 yards below Pen-y-wern, forms the last of the series of disturbances we have been discussing; northwards from it the strata rise steadily, the Trigloin cropping a second time, and then, in succession, the Bryn-lloi, Little Brass, Middle and Lower Veins. The last two are being worked with thicknesses of 2 feet 9 inches and 2 feet 10 inches respectively. A vein 2 feet 6 inches thick, and supposed to be the Brass, crops in a ravine almost in the axis of the syncline. Its identity is doubtful. A still lower seam than any yet mentioned crops out in the bank under Pen-y-wern. It is supposed to be the same as a seam 1 foot thick which was laid open in the foundations of a house 300 yards north-east of Llwyn-y-môch, and which probably represents the Astell Vein.

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* *Proc. South Wales Inst. Eng.* vol. xx, 1896–98, p. 384, and vol. xxi, 1898–1900, p. 2.

Cwm Llynfell.

In Cwm Llynfell a remarkable series of synclines and anticlines was explored in working the Brass Vein. They were described and shown in plan by Mr. Huxham in the paper referred to.* They range about S. 43° W., but are not recognisable either in the Twrch to the north-east nor in the ground to the south-west, where they must be intersected by the Cwm Llynfell Fault (p. 104). It was noticed as a somewhat unusual circumstance that the coals were workable both over the anticlinal crests and across the synclinal troughs.

The folding and overthrusting of the strata described in the preceding pages is almost wholly confined to the outcrop of the lower measures, and the Red Vein crops with great regularity round hill after hill. It would not be prudent, however, to assume that the lower strata under those hills are equally regular, for experience gained in other parts of the coalfield has taught that soft measures of this type, though highly contorted themselves, may be directly overlain by strata in which no disturbance is manifest.†

The Brass Vein was considered the best anthracite on the east side of the Cwm Llynfell Fault, but the Big Vein was thought to be superior to it on the west side. The Black and White Veins contained more ash, and the Little Vein more sulphur. In the Brass Vein the pyrites lay in one band, from 0 to 4 inches thick, and 6 inches from the top of the seam. The Red Vein also is worked as an anthracite, but in accordance with the rule that the degree of anthracitisation decreases upwards in the measures the seams above it may be more properly classed as steam-coals.

A. S.

The base of the Coal Measures north of Cwm Llynfell has been drawn at the summit of the Farewell Rock, the Astell Vein not being there known. A brown quartzitic sandstone exposed on the moorland north of Cefn-bryn-brân is probably the floor of the Lower Vein, but the ground to the south is deeply buried under drift, and nothing is known of the higher veins as far south as Ystrad-Owen. A vein which has been regarded as the Brass Vein crops in the brook at Bryn-Llynfell; but a trial-shaft sunk close by in 1901 struck at 6 yards from the surface what was probably the same vein, which however did not resemble the Brass Vein in any particular, but is probably a local vein between the Big and the Black Veins. The pit passed through the Black Vein and a boring was made to the Brass Vein, which was reached at 39 yards from the surface.*

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* *Proc. South Wales Inst. Eng.* vol. xx, 1896–98, p. 384, and vol. xxi, 1898–1900, p. 2.

† A. Strahan and W. Gibson in 'The Country around Merthyr Tydfil,' 1904, pp. 52, 60, 64, etc., *Mem. Geol. Surv*

South of the cemetery at Bryn Cwm Llynfell the river Llynfell crosses the outcrops of the Big, the Harnlo, the Little or Four-foot, the Upper Black and the Stwrain Veins; these and the accompanying ironstones appear to have once been 'patched' on the west side of the valley.

The same veins were worked on the west side of the valley from Cwm Llynfell Colliery shaft which began between the Stwrain Vein and the Upper Black Vein. Several sharp rolls were met with in the Brass Vein, the average direction being about W. 35° S.

Above the Stwrain Vein there follows a considerable thickness of measures devoid of coals of any value; one thin vein, however, was worked on the hill-side north of Pen-rhiw-fawr not far below the crop of the Red Vein. Two other small veins in shales are exposed at about the same horizon in the brook running by the side of the road from Pen-rhiw-fawr to Cwm Twrch. The same part of the measures contains blackband ironstone, one seam of which was got by a pit in the fields between Bryn-haul and Gelli-warog.

The Red Vein.—Not many yards above these beds lies the Red Vein. It crosses Nant Cwm-du south of Bieting, and has lately been opened close to the stream by the Gilwern Colliery (close to the line of section on the one-inch map). Northwards from the stream the vein rises; it was worked by levels in the dingle south of Bieting and again west of Gelli-warog where it is still occasionally got; the coal is 4 feet 2 inches thick. Thence it can be followed as far as the Cwm Llynfell Fault at Pen-rhiw-fawr. For a list of fossils collected here see pp. 94, 95.

From the Cwm Llynfell Fault to Garnant.

The Cwm Llynfell Fault is a large westerly downthrow. Its throw may be estimated on the following evidence. On the east side of the fault, at 400 yards north-north-west of Coed-y-ffaldau Farm, an air-shaft by the roadside is said to have been sunk 20 yards to the Little Vein. The Red Vein crops out on the west of the fault a few yards away. The true thickness between the Red and Little Veins is about 290 yards, which indicates a throw of about 270 yards. Another account of the air-shaft states that it was 70 yards to the Little Vein, which would reduce the throw to 220 yards. Another method can be based on the shift of the Brass Vein crop. East of the fault this vein would crop somewhere under the village of Ystrad-Owen; west of the fault it crops in the mouth of the Blaen-cae-gurwen slopes. The shift is about 1,000 yards, which, with a dip of 7 inches per yard (as at Blaen-cae-gurwen), would give a throw of about 190 yards.

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* For this information we are indebted to Mr. John Roberts.

West of the fault the base of the Coal Measures is shifted northwards, and has been drawn at a thin coal known as the Astell Vein, which almost immediately overlies the Farewell Rock in Cwm Garw, where it was formerly worked. The next higher vein, the Bryn Vein, is probably the thin coal once worked at Cwm-nant-gwyn (between Rhôs-Amman and Brynamman) where it is associated with shales. Farther west there are old drifts upon it in Cwm Garw opposite Rhosfa, and the rock which here overlies it forms a steep bank on the west side of the valley as far south as the bridge.

West of this the outcrops are shifted northwards by the Brynamman Fault, a westerly downthrow. A thin vein, probably the Astell, was proved in Nant-melyn a quarter of a mile above Bryn-uchaf. The Bryn Vein, with its overlying rock, crosses the same brook below Bryn-uchaf, and the coal may be seen in the brook, and has been worked by levels. The rock is quarried to a depth of 30 feet for building-purposes. Thence the coal can be followed north-westwards by old sinks and cropworks to Bryn-uchaf and Pleasant View, beyond which it passes under the boulder-clay of Nant Gwineu.

The next higher veins include those from the Lower Vein to the White Vein; they crop out along the Amman Valley west of the Cwm Llynfell Fault. The crops of the Lower and Middle Vein were worked at Rhôs-amman, and the Rhôs-amman Colliery shaft passed through the Little Brass Vein to the Middle Vein at 25 to 30 yards and the Lower Vein at 35 to 40 yards. Logan* records the thickness of the veins as 1 foot 6 inches, 2 feet 6 inches, and 3 feet respectively. On the south side of the valley the succeeding veins crop out, and with the ironstones have all been patched and worked by shallow pits and slopes. The Blaen-cae-gurwen main slope is in the Brass Vein, the old Blaen-y-waun Drift worked the higher veins from the Big to the White, while the ironstones associated with the Little, Black, and White Veins were extensively patched. There are 5 yards of ground between the last two veins, and the Black Vein is 1 foot 6 inches thick; the Upper Pencraig, close above the Little Vein, is 1 foot 2 inches thick.

West of these workings a fault passing under Tir-hên throws all the seams about 40 yards up west; the throw being given by the fact that on the east the crops of the Big and the Little Veins are brought respectively against those of the Brass and the Big Veins on the west. Also the fault was touched on the east in the Little Vein workings. By this fault the crops are shifted southwards; the Lower and Middle Veins crop at Tir-hên and were worked at a colliery there; they then crop on the south side of the river Amman, and the Middle Vein, 2 feet 10 inches thick, was opened-up in 1899 by a slant at Cwm-têg Colliery. A railway cutting at Tir-hên-isaf shows the Little Brass Vein, 2 feet thick, and the Middle Vein with 27 feet of shales between. The Lower Vein was worked by a shaft by the side of the Garw a little farther west. The succeeding veins, from the Brynlloi to the Big, crop out on the south side of the Amman Valley, and together with the ironstones were all to some extent worked. South of Cors-tô there are one or two rolls and small overthrusts in the Big Vein with a direction of about E. 30° S., and having the effect of downthrows to the N. 30° E., to the extent, in one case, of about 12 yards.

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* In a MS. note-book, entitled 'Notes and Sections relating to the S. Wales Coalfield by Sir William E. Logan (then Mr. Logan), 1836 to 1842,' preserved in the Geological Survey Office.

West of this the Brynamman or Llwyn-y-celyn Fault, a downthrow west, crosses the outcrops; it brings the Middle against the Lower Vein, which indicates a throw of about 16 yards. Farther south it has been proved in the Big Vein from Gwaen-cae-gurwen to be 10 yards and ultimately to die out near Llwyn-y-celyn. West of this fault what is supposed to be the Lower Vein crops out in Nant-melyn at the bridge near Brynamman Church; there is an old crop-work on what is probably the same vein some quarter-mile west on the south side of the Llandilo road; and the vein probably crops just north of the same road at Pen-waun-ynys, where a trial shaft is said to have reached the coal.

The Middle Vein crops in the bed of the stream in Cwm-nant-moel at Brynamman, and the Little Brass is to be seen in the bank. The Middle Vein has been worked by a slant from the crop at Pen-waun-ynys and together with the Lower Vein was worked by a drift at Ynys-dawela; while what is probably the Little Brass Vein has been worked along the crop between that place and Cornel-fâch, where the crop is repeated by an anticline visible in the Amman. In the railway 300 yards south-west of Brynamman Station (G.W.R.) another sharp anticline is exposed, while in the river-cliff a little farther south-west two anticlines are exposed. That in the railway probably continues as the more westerly of these.

The succeeding veins and the ironstones have been worked by patches and slopes on the south side of the Amman Valley, and the Amman Pit was sunk from the Trigloin Vein to the Lower Vein, which was found to be crossed by several slight rolls having a north-east and south-west range. The Trigloin Vein at Pant-y-celyn Slope is said to be 2 feet 4 inches thick.

The Gwaen-cae-gurwen old shaft was sunk to the Big Vein which is 3 feet to 4 feet 8 inches thick; that and the Brass Vein 36 yards below and 2 feet 10 inches to 4 feet thick have been worked to the north towards Brynamman. Balls of black pyrites are met with at 1 foot from the bottom of the Big Vein and a 3 inch band of pyrites is present in the Brass Vein at 8 or 9 inches from the top. In the Brynamman district the Lower Black Vein is said to be unworkable on account of containing too much sulphur.

West of Glyn-y-beudy the Brynlloi Vein was worked on the south side of the river opposite Ynys-dawela, and may be the vein which crops at the side of the railway north of the Neuadd Colliery. This colliery was opened in 1901 on the crop of the Trigloin Vein, and the following section of the coal was supplied by Mr. Walter Lewis :—

		Ft.	In.
	Clift	—	—
Trigloin Vein 4 ft. 2in.	Top coal	1	4½
	Pinchin		1½
	Bottom coal	2	8
	Very soft clay		5
	Fireclay (hard)	3	11
	Sandstone (hard)		5

Above this group of veins there follows a considerable thickness of ground occupied by Gwaun-cae-gurwen, devoid of workable coals; these measures were passed through in the Gwaun-cae-gurwen shafts and contained several coals the thickest of which was 1 foot 10 inches. At Pwll-y-wrâch a massive sandstone crops out and forms waterfalls in the Garnant; it is to be seen farther east in a railway at the Gwaun-cae-gurwen Colliery screens and in quarries near Llwyn-y-celyn. Above the sandstone a thin coal (about 9 inches) has been worked at Cwm-nant-hîr, and is possibly the one-foot coal which crops in a stream south of Gwaun-cae-gurwen New Pit (1884) and in a disused railway-cutting a little farther south.

The *Red Vein* crops out along the foot of the escarpment south of Gwaun-cae-gurwen, and has been worked along the crop from the Cwm Llynfell Fault westwards along Tyle-penlan. At Bwlch-y-bryn-du it is said to be thrown down west 16 yards, but there is no evidence of this on the surface. A little farther west it has been opened up by the Brook Colliery slopes belonging to the Gwaun-cae-Gurwen Colliery Co.; it is here 3 feet to 3 feet 3 inches thick. At Bryn-du it was worked on the crop and is said to be thrown down east by the Tir-hên Fault, but there is no evidence of this on the surface. For a list of fossils collected at Brook Colliery see pp. 94, 95.

The Red Vein south-west of this point has been worked north-east of and at Wern-bwll, where Logan (MS., 1836–42) found a pit on a vein said to be 2 feet thick and regarded locally as the Red Vein, but which he inclined to think was some higher local coal. At Pen-cae-du there are old pits and slopes close to the crop of the vein, and the coal is exposed at Heol-hîr east of Beili-glâs; the descending succession being sandstone resembling pennant, shale, coal (Red Vein) 3 to 4 feet, and fireclay. The vein was more extensively worked at the old Mountain Level. At Pen-cae-du it is said to be cut by a downthrow west of 8 yards; there is no evidence of this on the ground, but a syncline was proved in the vein from the Mountain Level close to the line of a supposed easterly downthrow ranging from Cwm Egel. The vein is now worked at Cwm Gors Colliery and averages 4 feet to 4 feet 6 inches thick. *Carbonicola aquilina* ? J. de C. Sow. sp., was found here by Mr. J. Pringle.

Above the Red Vein sandstones of the pennant type and corresponding to the Llynfi Rock group produce a bolder type of scenery, the soft flat ground of Gwaun-cae-gurwen giving place to a steep scarp which leads up to the plateau of Penlle'r-fedwen. These sandstones appear south of Tyle-penlan west of the Cwm Llynfell Fault; a quarry 300 yards west of Pant-y-bara shows:—

	Ft.	In.
Sandstone, false-bedded, seen to - - - - - -	20	0
Coal and fireclay, not worked - - - - - -	1	6
Shale - - - - - - - - - -	6	0
Sandstone, seen to - - - - - - - -	8	0

This quarry illustrates the general occurrence of a vein of coal above shale and below sandstone in and immediately below the Pennant Series. Farther south by the brook-side below Blaennant there is a stone-quarry in the same or a slightly higher bed.

Some sandstones at about the same horizon crop out in several brooks at Blaen-nant-hîr and have an aggregate thickness of some 30 or 40 feet. Above this some thickness of shales follows, in which a coal 2 feet thick has been worked on the hill south of Blaen-nant. The Bryn-melyn sandstone, not far above, overlies an impersistent coal said to be 1 foot 8 inches thick; the shale of the roof is said to have yielded 9½ gallons of crude oil per ton. The sandstone itself was extensively quarried and carried down an incline to the Gwaun-cae-gurwen branch of the railway. A band of light-grey quartzitic sandstone of the cockshot type crops out a little farther south, closely followed by a coal which we have taken to be the representative of the Ynysarwed Vein or base of the Pennant Series.

South of Gwaun-cae-gurwen and along the eastern side of Cwm-y-gors the sections are not so clear; a small vein not far above the Red Vein has been worked at Llwyn-rhidiau, and others somewhat higher in the series crop out on the side of the valley farther south, above Aber-nant Inn and in the brook below Llwyn-hên, where the vein is 1 foot 6 inches thick. Still higher in the series a vein has been worked along the crop on the mountain above the last-named place; and another, still higher, and said to be 1 foot 4 inches, was worked at Cwm-nant-Hopkin.

From Garnant to the Ty-llwyd Fault.

West of Brynamman a thin seam of coal serves conveniently as the arbitrary base of the Coal Measures; at Bryn-pedol a coal-smut to be seen at the top of a shale-cliff on the left bank of the river is probably the Astell Vein, but, if so, it has a greater thickness of shales between it and the Farewell Rock than was the case in

Cwm Garw, Brynamman. West of Cwm-Pedol the Astell Vein is unknown, and the base of the Coal Measures has to be drawn at the top of the Farewell Rock, a clearly defined line.

The Bryn Vein may possibly be represented by a thin vein on which a drift was driven on the left bank of the Pedol opposite Hendre-fawr; but as the drift is said to have been for ironstone and not coal, and as the roof is of shale and not rock, this identification is doubtful. At about this horizon a sandstone crops out in the fields west of Hendre-fawr and is possibly the same as that quarried at Glyn-dreiniog.

West of Ynys-dawela there are several old drifts in the north bank of the Amman, said to have been for the Lower and Middle Veins; the rock quarried at Tir-Sir-Walter is said to be 23 yards above the Lower Vein, but it is more probably less, and may be below the vein. These two veins are said to crop in the Garnant; the one a few yards south of the Brynamman railway bridge, the other a little farther south-east at the foot of the Gwaun-cae-gurwen railway embankment; while north-west of the Raven Inn there are several old drifts to the Middle Vein.

The succeeding veins cross the Garnant Valley between Neuadd and Pwll-y-wrâch, and with the ironstones have been patched and worked by slopes and levels, and also in the Garnant Pit. Nothing seems to be known of the Little Brass Vein here; the Brynlloi crops in the Garnant between Neuadd and Tir-bâch; it was got by a shaft 25 yards deep at the old Gors-y-Garnant Colliery and crosses Nant-y-gath at the Raven Colliery, where together with the associated ironstones it was worked. The Raven Drift started a little below the Brynlloi crop and worked that and the Trigloin, Brass, and Big Veins. The Brynlloi and also the Trigloin Vein were got in the old Nant-main Drift.

The Trigloin Vein crops in the grounds of Tir-bâch; it was patched west of the Garnant and in both sides of Nant-y-gath. The Brass Vein was opened in 1899 by slants at Glan Garnant Colliery, Tir-bâch; it proved to be 2 feet 9 inches to 3 feet 4 inches thick. There are patches on it in Nant-y-gath also. The Lower Black Vein was proved in 1899 east of Tir-bâch; there is an old patch on the ironstone above the Big Vein south-east of Tir-bâch, and again west of the Garnant; there is a development of about 10 feet of sandstone above the vein. This Big Vein rock is better seen where it crosses Nant-y-gath; it forms the top of an old patch west of the stream.

The higher veins—the Harnlo, Little or Lower Pencraig, Black, and White Veins—successively cross the Garnant above the Globe Inn, and have been worked and patched both there and also in Nant-y-gath at Bryn-cam.

The Garnant Colliery shaft was sunk to the Trigloin Vein and proved some of the coals above the Big Vein.

The Logan MS. records that at Bryn-gam (500 yards south of the present Bryn-cam) there is a band of stone 24 feet thick with shale-partings; he thought it probably the same as the Pwll-y-wrâch rock.

The *Red Vein* west of Cwm-y-gors has been worked by little shafts near Gelli-fawr and the crop can be traced thence by old pits and slopes to the new Cawdor Colliery at Bryn-cethen. Here the vein is 4 feet to 4 feet 6 inches thick and has an average dip towards a little west of south at 5 inches per yard. For a list of the fossils collected here, see pp. 94, 95.

West of the Cawdor Colliery the crop can be followed by old workings to a point 150 yards west of Cwm Helen, where the workings cease, and the crop is thrown down and shifted northwards by the Ty-llwyd or Nant-main Fault, though here the throw cannot be nearly so great as in the lower coals farther north in Cwm Amman, and a little south of the Red Vein the fault seems to die out.

Above the Red Vein follow shales, succeeding which a bed of cockshot rock can be traced from Gelli-fawr on the west side of Cwm-y-gors as far as Banc-cwm-Helen. Immediately below this cockshot band is a blackband ironstone which was got at a level west of Gelli-fawr where there are large masses of the calcined ore. There are several old trial-levels at the same horizon farther west, at one of which, by the brook-side south-west of Pant-yr-eithin, there are signs of coal. Some old crop-works a little farther south if on a coal at all may have been on the seam that was worked at Cwm-buarth-gau, half-a-mile farther west.

South of Nant-Rickett in Cwm-y-gors a still higher coal said to be 2 feet to 2 feet 6 inches thick, under a shale roof, has been worked, and a flaggy sandstone 25 feet or more thick has been quarried a few yards above it. The coal runs northwards and turns up Nant-Rickett, and runs round the plateau as far as the Nant Garenig Fault. Presumably this is the vein which was worked at Cwm-nant-Hopkin in Cwm-y-gors.

From the Ty-llwyd Fault to the Nant Garenig Fault.

West of the Ty-llwyd Fault, a large downthrow west which is said to throw the crop of the Big Vein against that of the Lower Vein, and thus to amount to some 100 or 150 yards, the lower measures are obscured by boulder-clay, and the position of their base is largely conjectural. An olive-brown sandstone, seen under boulder-clay in Nant-glâs, west of Aber-nant-glâs, resembles the Farewell Rock, and in the Berach about half-way between Pen-twyn-côch and Tir-y-coed a trial-pit got a small vein possibly corresponding to the Astell Vein. A higher coal, said to crop under some houses on the Llandyfan road 250 yards north of Bridge Row, may represent the Bryn Vein. In the shaft of the Ty-llwyd Colliery the Middle Vein was identified at 22 yards depth, but as a small coal visible a few yards from the shaft was said to be the Little Brass Vein, the coal in the shaft is more likely to have been the Lower Vein. This probably crops just south of the farm. Old workings extend westwards as far as Nant Berach.

A shaft at Brynlloi Colliery went down 50 yards to the Middle Vein, and the Lower Vein also was worked. In Nant Garenig there are old trials on higher veins which could not be identified.

The Brynlloi, or Little Vein as it is known here, crops out at the foot of the steep ground south of Glanamman village; a pair of slopes was recently begun near the outcrop, and at the old Brynlloi Colliery there was a drift to the vein.

The Trigloin Vein was worked at the old Middle Amman Colliery (now buried under Gellicaedrum tips), and there are old pits and levels running round the hill towards Cwm Garenig. The Brass and Big Veins are worked at Gellicaedrum Colliery, and have been got westwards; the latter crops at or near the top of the incline on the old Cawdor Colliery tramway, and a grey sandstone above it about 20 feet thick is quarried for building below Gelli-caedrum-uchaf. Above the quarry there is an old patch on the Pencraig Vein. Near the road running up the east side of Cwm Garenig there are old pits from 20 to 30 yards to the Big Vein; they are about a quarter of a mile north of Hendy.

The Logan MS. mentions several thin veins (up to 2 feet) as cropping near Bryn-henydd, not far below the Red Vein.

The *Red Vein* west of the Ty-llwyd Fault has been worked by windlasses at Pen-y-bwnsion and Pant-y-ffynnon, and the crop can be traced to the old Cawdor Colliery at the top of Cwm Garenig, west of which the vein is thrown down by the Nant Garenig Fault into the Amman Valley. The throw of this fault was estimated by Logan thus: the crop of the Red Vein is thrown into line with that of the Trigloin Vein; the distance from the Red Vein to the Big Vein being, say, 220 yards; from the Big Vein to the Black Vein, 16 yards; from the Black Vein to the Brass Vein, 17 yards; from the Brass Vein to the Trigloin Vein, 24 yards—the throw would be 277 yards. But the distance from the Red Vein to the Big Vein is nearer 360 yards, which would make the throw in round numbers 400 yards.

Below the Red Vein at Twll-gwyn there is an excellent bed of sandstone which was formerly quarried for flags (p. 222).

The Red Vein was worked to the Nant Garenig Fault under the Garenig-fâch from the old Cawdor Colliery, and its crop can be followed on the surface up to the fault. Three hundred yards south of it, at the foot of a crag of massive sandstone overlying nodular shales, there are several old levels for blackband ironstone, of which there is a calcined heap by the Garenig-fâch. A few yards farther up a cascade is formed by sandstones resting on shales; the sandstone is slickensided by the Nant Garenig Fault. On a moorland stream half a mile to the south-east a small vein has been worked near the ruins of Cwm-buarth-gau.

At the Garenig-fâch the Nant Garenig Fault throws off the Glyn-môch Fault, also a downthrow west of some 200 or 300 yards, which, however, rejoins the main fault north of the Amman Valley. Of the seams below the Red Vein between these two faults nothing is known, the whole ground being overspread with boulder-clay; a trial-drift into the old bank of the river 200 yards east of the Farmer's Arms was made recently in search of the Big Vein.

The *Red Vein* west of the Nant Garenig Fault is being worked, with a thickness of 4 feet to 4 feet 6 inches, at the Dyffryn Amman slopes, north of Cwm Garenig Farm; it has also been got in a brook west of Ty'n-y-graig, where it is overlain by a rock and underlain by shales.

Above the Red Vein two veins have been worked; one crops out by the side of a roadway 300 yards south-east of Cwm Garenig Farm, where in a level it is 1 foot 6 inches to 2 feet thick, with a sandstone above it; and what is probably the same vein has been tried on the mountain at Penlle'r-eglwys. About a hundred yards farther south a parallel line of old levels marks the crop of a higher vein, 2 feet thick, which we have taken to represent the Rhondda No. 2 Vein or base of the Pennant Series. A little to the south-west of these levels the line of the Glyn-môch Fault is marked by the sparry condition of some sandstones at the head of a deep gully in shales at Banwen.

Forge Llandyfan and Dre-fâch.

It has been mentioned already (p. 85) that what we have taken to be the Farewell Rock at Forge Llandyfan is succeeded by black shales which therefore are attributed to the Coal Measures. They are to be seen in the sides of the road a few yards south-east of Glan-y-quay, and still better in the brook south-east of Garn-lwydwen. There is no evidence of their containing workable coals.

East of the Nant Garenig Fault at Dre-fâch on the Loughor the brown sandstone which we have taken to represent the Farewell Rock (p. 85) dips south-west under shales which must therefore be assigned to the Coal Measures. The shales themselves are soon succeeded by a band of quartzitic grit which is visible in the river at Creigiau, and this again by shales. There is no evidence of coals in this little patch, and immediately south-west of these sections the Nant Garenig or Llandyfan Fault throws in the Coal Measures much more deeply.

From the Nant Garenig Fault to the Bettws Fault.

The base of the Coal Measures is carried by the Nant Garenig Fault from the Amman Valley north-westwards into that of the Loughor near Llandyfan. The Farewell Rock comes to the surface as an anticline in Glyn-hîr Park (p. 86) also, so that the lowest Coal Measures must crop out around it. Unfortunately, however, the ground is greatly obscured by boulder-clay so that between Llwyn-yr-hâf in the Amman Valley, Glyn-hîr, and Ammanford the Coal Measures are almost wholly concealed.

The lowest beds overlying the main outcrop of the Farewell Rock are exposed a quarter of a mile south of Garn-bica in a lane leading to Glyn-hîr Mill; a band of grey and yellow sandstone in places quartzitic and containing rootlets crops out a few yards above the base, but there seems to be no coal representing the Astell Vein. These beds dip south-east at 30° towards Nant Gwyddfan, in which there is a small section of shale immediately south of Glyn-powys, while a small section in a ditch at Tir-Ifan shows shales over grey sandstone, dipping north-west at 45°. A synclinal axis must therefore run somewhere under Glyn-powys, and a little south-east of Tir-Ifan the Farewell Rock crops out at Glyn-hîr. That this syncline is deep enough to bring in workable coals is rendered probable by the fact that on the north-west bank of the Gwyddfan, 300 yards below Glyn-powys, there are some little old pits which are probably those referred to in the Logan MS. as on the Pumpquart Vein, 3 feet 6 inches thick. This would be the Lower Pumpquart of the Llandybie district and corresponds approximately to the Lower Vein of the Amman Valley.

Presumably the vein dips steeply to the north-west, and, if so, must crop out again farther north beyond the syncline.

Still proceeding towards the south-east the Coal Measures come in again in the Loughor Valley, and at Cwm Llwchwr Woollen Factory fine-grained grey quartzite is seen by the roadside, dipping E. 30° S. at 10°. As observed by Logan, it runs up the dingle to Glyn-hîr, a cliff on the east bank of the river a quarter of a mile below the well-known waterfall affording a section of:—

	Ft.	In.
Shale - - - - - - - - -	24	0
Coal - - - - - - - - -		6
Quartzite, fine-grained - - - - - -	12	0

Below are several feet of shales, and lastly quartzite, on the western edge of the river. The 12-foot band of quartzite is probably that of the woollen factory. The waterfall, east of Glyn-hîr House, is formed by a shelf of hard grit 3 feet thick, overlying 15 feet of alternating grits and shales in bands 1 to 2 inches thick. The beds dip N. 5° E. at 4°, and the hard shelf of grit overlying the softer beds has resulted in the formation of a waterfall.

Above the waterfall the grit, after occupying the river-bed for some 300 yards, passes under shales containing thin bands of grit and sandstone at Glyn-hîr Mill. In the eastern bank of the river here the shales, which dip E. 35° N. at 18°, suddenly flatten and then plunge down vertically, striking east and west; but the nature of the disturbance is obscure. A dip of 76° to the north or north-west prevails up stream, till a little below Creigiau we reach some large old openworks on some veins of coal and ironstone. There seem to be at least two or even three outcrops of coal, but whether these are one and the same vein repeated by folding, is difficult to say, for the beds are highly inclined or vertical. Logan saw one of the veins, and gives its thickness as 1 foot. According to him the Lower Pumpquart was included among them. The coal and ironstone are said to have been used at Forge Llandyfan for the manufacture of edged tools many years ago.

On the north-east these veins are cut off by the Llandyfan Fault; in the opposite direction they strike about west-south-west, towards Glyn-powys. Probably they dip generally to the north-north-west, but rise up again to the north under the boulder-clay and strike towards Llandybie, where they must run into the Dinas Fault.

Beyond Glyn-powys the outcrops presumably curve round into Cwm Llwchwr. A vein of coal crops out at the top of a wood on the east side of the valley about a quarter of a mile north-east of Cwm Llwchwr Woollen Factory, and was found about 1901 by Mr. Ivor Morris to be 2 feet 10 inches thick, but whether this is one of the Creigiau veins or a lower one is uncertain. Farther south there are few sections; black quartzitic grit apparently in place is seen in the brook at Cefn-cenfi, and a little farther down stream the left bank presents a cliff 18 to 20 feet high of shales with ‘mine,’ at the top of which a coal-smut is visible. A few yards still lower, at Pen-twyn, there are old levels in mine-ground, and shales are exposed down stream nearly as far as Cae’r-ogof. According to a local tradition, many years ago a boring was put down, near the ford on the Loughor below Parc-Henry, to a depth of 30 yards without meeting with any coal; and another, by the roadside 300 yards west of the ford, is said to have reached shale but no coal.

A mile farther east, there are sections in shales in a brook below Hannereg-fâch in what must be higher beds, but no coals appear to be known here.

At Llwyn-yr-hâf, however, in the Amman Valley, and not far west of the Glyn-môch Fault, we have a source of definite information. In 1840 a pit was sunk by the side of the river Amman 200 yards east of the lower of the two places named Llwyn-yr-hâf on the six-inch map (Carm. 49, Glam. 2, N.W.); in it the Big Vein, 6 feet thick, was reached at a depth of 135 yards. The beds dip about S. 50° E. at 20° or 13 inches per yard. Also, 200 yards west-north-west of the pit, and 70 yards north of Llwyn-yr-hâf, a drift was made in a north-west direction towards Abernant, to reach the Big and Brass Veins to the rise; it cut what is probably the Lower Pencraig Vein, 1 foot 4 inches thick, the Big Vein, 6 feet thick, the Lower Black Vein, 4 feet, and the Brass Vein 3 feet. A still lower vein containing 1 foot 7 inches of coal and 9 inches of parting may represent the Trigloin Vein, while another vein 1 foot 4 inches thick, lies 12 yards beyond it and rather too high for the Brynlloi. There are old pits to the Big and the Brass Veins in the wood east of Abernant, from one of which, by the brookside, said to be 27 yards to the Brass Vein, a little coal had been raised in 1901. The crop of the vein would run under the stream near Abernant, but west of this nothing is known till we reach Pontamman.

Here there are old levels and pits: one about 250 yards due south of the bridge, another on the edge of the alluvium at Pen-twyn; and a little farther south, on the edge of the old river-terrace, there are several old trial drifts. At the first two of these, coal appears to have been got, and though tradition refers the vein to the Brass, its identity is doubtful. The workings of the Ammanford Colliery * have thrown little light on the question. No. 2 drift ascended in the measures, and struck the supposed Brass Vein, 3 feet thick, then the supposed Black Vein, 2 feet 8 inches, and then the supposed Big Vein, 6 feet. The drift then passed at about 120 yards from the mouth through a fault, or probably a thrust, into a rock, and beyond this struck a vein 1 foot 3 inches thick. This was followed to the deep, with a dip of 44°. This vein was soon left, and the drift was directed across measures into higher beds into a vein which was called the Little Vein (which is the vein now worked) with an average dip of 9 inches per yard, then into the supposed Black Vein, and beyond that into the supposed Big Vein, a vein subsequently proved in two boreholes on the property. From this evidence it seems certain that the fault met with in the slopes is an overthrust with downthrow north, by which the veins are made to crop out twice.

The two boreholes were put down in 1896 to prove the ground farther south. No. 1 was put down on the west side of Nant-melyn at 100 yards south-east of Gwern-y-felin; No. 2 was sunk in the angle between Glyn-cywarch brook and Nant-y-ffîn, at about 50 yards from the confluence, and not many yards below the crop of the Red Vein, and the two boreholes together must have proved the ground from just below that vein for a thickness of about 400 yards.

The sections of the boreholes agree fairly well in themselves, but do not compare with the Llwyn-yr-hâf section farther east; and all that can be said is that if the vein with numerous partings met with at 170 yards and 241 yards in boreholes No. 1 and No. 2 respectively be the Stanllyd, then the so-called Little Vein now being worked is probably the Brass Vein, and the lowest group of coals found in No. 1 borehole would then represent the Little Brass, Middle, and Lower Veins of Brynamman, and the Ty-llwyd Veins of Cwm Amman.

The sections in Nant-y-ffîn expose some of the higher beds. Near Glan-nant-y-ffîn an old stream-bank shows shales-with-mine; at the foot of it a trial-slope proved a thin vein. On the north side of the stream, about 100 yards east of Maes-y-Bettws, the Ammanford Colliery Company put down a trial-shaft to a depth of 30 yards; at the bottom a drift was driven 30 yards to the rise, when a vein 4 feet 6 inches was struck.

A little higher up the stream an old level in shale-with-mine is

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* For information on this colliery we are indebted to Mr. E. Hewlett.

to be seen on the south bank of the stream, and just south of the bridge under the Llandilo-Neath road there is an old slope on a vein of coal which may be a vein 3 feet 4 inches thick (including a 3-inch clod) met with at 39 yards in the No. 2 borehole.

The *Red Vein* west of the Glyn-môch Fault was worked at Glyn-môch Colliery, the workings of which touched the fault about 300 yards from the mouth of the slope. The vein has been worked on the crop westwards; the coal is visible in a lane below Bodyst-isaf, and by the side of the lane there was a colliery called the Ammanford Colliery, abandoned in 1889; the coal was 4 feet 4 inches to 4 feet 6 inches thick, with about 2 feet of fireclay below it. The dip was 16 inches per yard. There are some old pits close to the crop in two brooks above Plâs-y-bettws, where there is said to be a downthrow or downfold west of a few yards. The vein has long been worked at Glyn-cywarch; the Logan MS. mentions pits here 15 to 20 fathoms deep. The Ammanford Colliery Company's slopes on the vein are here; the average dip is 9 inches per yard. A small east-and-west fault with downthrow south of 4 yards was proved under Llwch-is-awel. In the workings a clod makes its appearance in the vein and divides it into two, the section being as follows—coal 2 feet to 2 feet 3 inches; clod, 5 feet; coal, 3 feet 3 inches to 3 feet 6 inches.

West of Glyn-cywarch the crop can be traced with ease by old pits and slopes. At the old Dynevor and Maes-y-cwarau Colliery the lower part of the vein was worked. The most westerly working on the vein is a deep old shaft in a wood below Argoed-fawr; immediately beyond this the Bettws Fault throws down the measures on the west and nothing more is known of the vein. The fault was passed through in a water-adit (draining the Ammanford Colliery Company's Red Vein workings) a few yards east of a large quarry 400 yards east of Pant-y-bettws.

Above the Red Vein west of the Glyn-môch Fault two thin coals, the lower with a sandstone-roof, are visible in a lane just above Bodyst-isaf, west of which they are not known. At Brunant, just west of the fault, there are old crop-holes on a vein, probably a foot thick, which is visible in a lane at Bodyst-uchaf, and thence runs somewhat sharply down hill in a south-south-west direction; it is exposed in Glyn-cywarch Brook 250 yards above Castell-du. It next crosses a brook half-way between Llethrlan-fawr and Tir-Eleanor-Morgan, the descending section being sandstone, brown shale 3 feet, coal 1 foot, and underclay; beyond this point its outcrop is unknown.

In Nant-y-ffîn, 200 yards south of the crop of the Red Vein, a small coal has been worked on the crop; it appears to be about 50 yards above the Red Vein. Still farther up stream there are hard sandy shales with thin irregularly-bedded bands of quartzitic sandstone, which make a good feature below Maes-y-cwarau, and at Argoed-fawr, but a little farther west these beds abruptly end against shale-ground brought in by the Bettws Fault. This 'cockshot' rock lies about 350 feet above the Red Vein. A few yards beneath it, below Maes-y-cwarau, there is a line of old crop-works on a thin coal or band of ironstone. In or immediately above the cockshot band a bed of blackband ironstone was proved in Nant-y-ffîn.

Above the cockshot thick sandstones alternate with shales, and may be regarded as representing the Llynfi Rock of districts farther east. The whole group has a thickness of about 900 feet. There is a large quarry in sandstone in Nant-y-ffîn, and another in the same bed north of Maes-y-cwarau. The succeeding shale-band contains a thin coal, and an old drift behind Maes-y-cwarau which now supplies the house with water seems to have been driven in search of coal. Between this and Gilfach there is a good section in a ditch, of shales with occasional mine-balls and three thin coaly bands. Above this shale-band follows another sandstone-bed, which has been quarried 150 yards south-east of Maes-y-cwarau; the next bed, of shales, contains at its base a thin coal on which there are some old pits in a dingle south-east of Llwyn-y-cwm. Above this a thick sandstone at Llwyn-y-cwm forms a bold feature, the base of which throws out several strong springs. Farther east, in the western branch of Nant-y-ffîn, there appears to be at its base a thin band of ironstone on which a level was driven at the brook-side.

From the Bettws Fault to the Bryn-gwili Fault.

The Bettws Fault is a great downthrow west; its position is well-defined in the cockshot band south-east of Bettws, as already related, and also in the Red Vein; north-west of Llandybie it is equally well-marked as the Dinas Fault in the Millstone Grit and Carboniferous Limestone, where its throw is about 200 yards. Between these two points its course under the superficial deposits is wholly conjectural, nor between Bettws and Llandybie has it been touched in any of the coal-workings; the nearest point on its line at which there is any evidence is at an old trial-pit sunk many years ago on the east side of the Llandilo Railway, 300 yards north of Tirydail Station; there is a shale tip and tradition records that a three-foot coal was reached, but this is doubtful.

Whatever disturbances may affect the Coal Measures east of the fault, between Glyn-hîr and Ammanford, the general cover of boulder-clay prevents our obtaining any knowledge of them; but west of the fault numerous surface-exposures and the various colliery-workings show that great complications exist; new names are adopted for the veins, and attempts to correlate them with the coals of the Amman Valley have met with small success. In the absence of the Red Vein, moreover, which is unknown west of the Bettws Fault, we lose a most useful datum-line.

On the west side of the Loughor and as far as Cross Hands the lower measures, which consist chiefly of shales, are thrown into a series of anticlines and synclines, having a general direction varying from east-north-east and west-south-west to north-east and south-west. Some of these rolls have a breadth of nearly a mile, but they are generally still farther complicated by sharp folds of only a few yards in width. The general nature of the ground is expressed more or less diagrammatically on the old geological map (41 S.E.), on which the coal-crops were laid down from sources of information no longer available. The anticlines often show dips steeper in the north-west than in the south-east limb. In some cases the folds have passed into thrusts of considerable magnitude; these may be either clean-cut fractures, or narrow belts of highly-disturbed ground; but in both cases the thrust makes usually a small angle with the vertical, and the beds above the thrust have moved generally towards the north-west. This disturbed condition of the measures becomes much less severe in the overlying Pennant ground, though there is reason to suspect the presence of more than one belt of sharp compression south of Cross Hands.

The following table exhibits the various names by which the several coals are known in different parts of the Llandybie district. The Brasslyd Vein of the Gors-gôch and western district is correlated with the Charcoal Vein of the Llandybie district, though with some doubt.

Coals of the Llandybie District.

Gorsgôch and west.	Emlyn.	Cae'rbryn.	Rhôs.	Panty-ffynnon.	Pontyclerc.
Big V.	Big V.	Rock V.	New V.	Upper V.	Rock V.
		Yard V.	Little V.	Little V.	Middle V.
Green V.	Green V.	Green V.	U. Pump-quart V.	U. Pump-quart V.	U. Pump-quart V.
[Ddugaled V.]	Cwmffaldau V.	?	Cwmffaldau V.	Coal 1 ft.	Coal 1ft. 2in.
[Hwch V.]	Bwla V.	?	Bwla V.	[Cwmffaldau V.]	Rocket V.
Stanllyd V.	Stanllyd V.	Stanllyd V.	Stanllyd V.	Stanllyd V.	Stanllyd V.
Gras-uchaf V.	M. Pump-quart V.	M. Pump-quart V.	M. Pump-quart V.		U. Fireclay V. ?
Gras-isaf V.	U. Triquart V.	U. Triquart V.	U. Triquart V.		L. Fireclay V. ?
Brasslyd V.	Charcoal V.	Charcoal V.			
Gwendraeth V					
L. Triquart V.					
L. Pump-quart V.					

West of the Bettws Fault the lowest Coal Measures may be seen at Blaen-nant-gwyn and Piodau-fawr, north-west of Llandybie. In a road passing through the farm-yard at the former a sharp little roll turns up the bare shales; and there are shales exposed on the Pentre-gwenlas mineral railway hard by. Between here and Piodau-fawr a crop of a vein, supposed the Lower Pumpquart, makes a sigmoidal curve. The vein, which was worked by pits and drifts, is said to be 3 feet to 3 feet 3 inches thick. Westwards it soon passes under the boulder-clay, which extends far up Cwm Lash.

The Lower Pumpquart Vein reappears in Nant Lash at Bryn-gwyn, three-quarters of a mile north of Pen-y-groes. Here the vein was worked by drifts driven northwards from the brook, and there are also old patches on the crop, and pits south of the crop at the old Cwm-y-nant Colliery, where the Lower Triquart also was got. A little lower in the series a thin vein crops in the brook, which may be the Little Vein below the Lower Pumpquart. Much more recently the Rock Castle Colliery (south of Castell-y-rhingyll) worked the Lower Pumpquart by slopes on the crop; and also the Lower Triquart. The former was followed down the full dip at about 2 feet in the yard (33°) which, at 300 yards down the slope increased to about 30 inches (40°), beyond which it flattened again. South-westwards the vein was worked to its crop under boulder-clay a little north of Gors-lâs Church, and the mine above it was taken to Llanelly by a tramway constructed in 1804. This tramline has been reopened as far as Cross Hands within the last thirty years as the Llanelly and Mynydd Mawr Railway.

West of Gors-lâs the outcrop of the Lower Pumpquart is obscured by the boulder-clay, but probably lies north of the road from Gors-lâs to Cwm-y-glo, for there a number of old shafts, probably sunk for ironstone, touched a coal also.

Here the line of the fault clearly marked in the Millstone Grit at Craig-y-geifr farther north (p. 178) appears to end the workings.

The present Cross Hands Colliery works the Lower Pumpquart and to some extent the Lower Triquart and Gwendraeth. In the upcast shaft the Lower Pumpquart Vein was reached at 50 yards depth and in the downcast shaft at 103 yards depth. A cross measure drift was cut in a south-east direction from the bottom of the downcast shaft and at some 70 yards distance got the coal, which was then followed by the main slope, at a dip of 13 inches per yard. It is evident that the shafts were sunk a few yards south of a line of fault—no doubt an overthrust—which has the effect of a downthrow north of about 50 yards. As the beds in the lower half of the downcast shaft all dipped steeply, it is likely that the thrust-plane is nearly vertical. This thrust presumably takes the usual east-north-east direction, and is commonly stated to range towards Bryn-y-fuwch, and to separate the Rock Castle workings on the north from those of California and Emlyn on the south. The extraordinary steep dip of the Lower Pumpquart in the Rock

Castle slope would be sufficient to bring in the Stanllyd and even higher veins north of the thrust; and some old pits at Pant-Hywel (300 yards south-east of the Rock Castle slopes) are traditionally regarded as having got the Stanllyd Vein. That vein crops at Bryn-y-fuwch, 300 yards farther south, and at a somewhat higher level, which, together with the dip of the rocks, would make the throw of the fault at least 300 or 400 yards.

If the overthrust at New Cross Hands is the same as that of Bryn-y-fuwch, it ought to have been passed through in the cross-measure drift between Gors-gôch Old Colliery and Gors-lâs. Although the records make no mention of any such fault having been met with, yet the distance between the Charcoal and the Brasslyd Veins as given in the section is abnormally great, a discrepancy explicable on the assumption that a fault with downthrow north somewhere crosses the drift, dipping south at a greater angle than the beds themselves (p. 125).

In 1901 some explorations were made in the New Cross Hands workings of the Lower Pumpquart Vein which proved some of the higher coals. A cross-measure drift was cut to the deep; the Lower Triquart lay about 7 yards above the Lower Pumpquart and was 2 feet thick; the Gwendraeth Vein was 50 yards above the Lower Triquart and was 2 feet 7 inches thick.* The Lower Triquart, if rightly identified, corresponds better with the position of the Little Vein 12 yards above the Lower Pumpquart at Pontyberem; while the Gwendraeth ought to be 77 yards above the Lower Pumpquart instead of 57.

Returning now to the ground immediately west of the Dinas Fault, it appears uncertain whether the Lower Triquart Vein was worked at Blaen-nant-gwyn and Piodau. In Nant Lash there are old crop-workings south-east of Glyn which may be on the Gwendraeth Vein, and others north of Blaenau Mill may be on the Brasslyd and Charcoal Veins, but not even a tradition survives as to the names of the veins. There are two old slopes on what is probably the Gwendraeth Vein by the side of the Gwendraeth 200 yards below Gors-lâs, and the Lower Triquart which appears to have been worked by a long drift from Gors-gôch Colliery probably crops a few yards farther north.

Of the Charcoal Vein little is now to be learned; it may be one of the veins which crop in Nant Lash between Blaenau Mill and Pont Lash. Farther south it is supposed to crop at Ysgubor-fawr. It is said to have been got in a pit north of Cwm-côch, and in the Logan MS. it is said to crop close to where the brook crosses the road west of the house, and a smut is still visible there; the coal is said to be 2 feet 6 inches thick. It may be the vein once worked in a number of old pits north of the peat-bog north-west of Pen-y-groes.

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* Information by Mr. D. F. Davies.

Above the Charcoal Vein the measures are better known; the Gras-isaf or Upper Triquart Vein, the Gras-uchaf or Middle Pumpquart, and the Stanllyd, may be treated together, the last two being generally associated in the present-day workings.

West of the Bettws Fault the crop of the Stanllyd Vein appears first at Pontyclerc, on the south side of the Pontyclerc overthrust, but the coal does not seem to be workable. Together with the associated veins it is thrown down northwards some 200 yards by the overthrust. At the old Park Colliery north of the thrust the Stanllyd Vein with an average thickness of 7 feet with locally a clod 1 to 24 inches thick was worked by a shaft 72 yards deep. At the present Park Colliery, where the Stanllyd and Middle Pumpquart Veins are worked, the former has been followed nearly to the surface under Wern-newydd, and doubtless crops under the boulder-clay a little farther north; it was found at a depth of 18 yards in the air-shaft and the Middle Pumpquart at 26 yards.

About 100 yards north-west of the Park slope a deep shaft was sunk, in which the Stanllyd was got at 44 feet depth, whereas, had the southerly dip of the vein in the workings continued, it should have been just about out of the ground; it is therefore probable that between the present slope and the shaft there is a disturbance having the effect of a downthrow north of at least 15 yards. At 132 yards or thereabouts in the shaft the Lower Pumpquart (the lowest workable coal in the district) was reached; and a level followed in it towards an older shaft, known as Glasbrook's Shaft, at Bryn-hyfryd, 250 yards to the north-west. At first the coal was nearly flat; it then plunged down to the north-west at about 45° and then ended against rock in a contorted and shattered condition. The drift was carried horizontally through this into the same coal again, which was found to be shattered and packed into much more than its proper thickness. The drift then rose through this 18 feet vertically, then entered rock again, and finally the same coal as before, lying nearly flat, and at about the same level as in the shaft. The coal was followed to Glasbrook's Shaft which it passed through at 130 yards depth. Beyond this shaft the level entered disturbed ground and was then abandoned. Of Glasbrook's Shaft, which is said to be 280 yards deep, no records are known to exist; but it would seem that it must have passed through the base of the Coal Measures and well into the Millstone Grit.

The general effect of these disturbances in the ground to the north of the Park slope amounts therefore to a downthrow north. Farther west, in a pit by a hedge-bank 180 yards south of Cwm-ffaldau, what is supposed to be the Upper Pumpquart Vein was reached at 9 yards. Mr. E. R. Fisher* found that in a shaft

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* To whom we are indebted for this and other information relative to the Coal Measures of the Llandybie district.

250 yards north-north-west of Nant-y-ci Cottage, sunk 65 yards, the Cwmffaldau Vein occurred three times, showing that the beds were over-folded from the south, and the Stanllyd and another vein below it were found still lower. A slope a little farther south-east, put down to reach the Stanllyd and Middle Pumpquart Veins, got into troubled ground.

North of this disturbed ground a shaft at Waun-lwyd reached the Stanllyd at 40 yards; and a little farther north, in the brook at Ysgubor-fawr, a number of veins crop out and were worked by pits, slopes, and patches; they include the veins from the Stanllyd to the Charcoal, and possibly some of the veins above and below these. The Logan MS. records that here the Stanllyd is 30 to 42 feet above the Middle Pumpquart (3½ feet thick), which was being worked in 1838; the Middle Pumpquart is 90 feet above the Triquart; the Charcoal Vein is 1 foot 6 inches thick; at Gilfach-Iago there was a pit 22 fathoms to the Big Vein which was 5 feet thick, and 3½ fathoms lower the Pumpquart was 3 feet 9 inches thick; the coals dipped north at 24 inches in the yard. More recently the Blaenau Colliery worked the Stanllyd and Middle Pumpquart by a drift.

From the brook at Ysgubor-fawr the Stanllyd and associated crops, which there dip about south-south-west, swing round to the north-east near Pont-y-blodau (where the beds are contorted, but probably on the whole dip north-west), and cross Nant Lash at Lower Glan-lash (below Pont Lash). Here the beds in the Lash in front of the house dip N. 20° W. at 70°. A rock is visible, which Logan (MS.) remarks looks like the top stone of the Stanllyd Vein, and he records that the Pennypieces Mine is visible. Local tradition now refers the rock to that above the Upper Triquart; the coals which crop out being the Bwla, Stanllyd, Middle Pumpquart, Upper Triquart, and Charcoal Veins. From this section the crops must run E. 20° N., but soon turn round the end of a syncline and range south-west again. This syncline is very clearly proved in the workings of the present Pont Lash Colliery, where the section of the winding-shaft is given as follows:—

Pont Lash Colliery.

	Ft.	In.
Measures, about	21	0
Bwla Vein (so-called 'Green Vein')	—	—
Measures, about	51	0
Stanllyd Vein (worked)	4	6
Measures	21	0
Middle Pumpquart Vein (worked)	3	3
	100	9

The so-called Green Vein (= Bwla) is supposed to crop about 10 yards up a brook on the west side of the bridge; and higher up the Lash about 150 yards above the bridge some old crop-works on the south bank are attributed to the Stanllyd; the Middle Pumpquart and Upper Triquart are supposed to crop still farther up-stream; but although these veins probably do crop hereabouts, the identification of any one of them is extremely doubtful in ground traversed by such sharp anticlines and synclines as are exposed, for instance, on the river at Cwm, and south of Glynglâs, for the same vein may crop more than once.

Before resuming our description of the veins west of Pont Lash we must briefly consider the ground about Dyffryn and Tirydail. This district is everywhere covered with boulder-clay and much uncertainty prevails as to the veins proved at the Tirydail Colliery. The disturbance proved in the cross-measure drift between the present Park shaft and Glasbrook's shaft (p. 121), and having the effect of a northerly downthrow, conceivably extends eastwards and separates the ground proved at Park from that of Tirydail. Were it not for this disturbance only the veins below the Stanllyd would occur at Tirydail, whereas it has been supposed that the Stanllyd and even higher veins are thrown in.

The Tirydail colliery* is worked by a drift which descends in the measures in a south-west direction. What is believed to be the Lower Pumpquart is the only vein worked. The dip is about S. 10° E. at 2 to 4 inches per yard, and the vein averages 3 feet 2 inches thick. The roof contains lamellibranchs (*Carbonicola turgida*, Brown sp., and *C. acuta* ? J. Sow. sp., as determined by Mr. E. T. Newton), a character which is found to mark the Lower Pumpquart roof at Park, New Cross Hands, and Pont Henry. The sequence appears to be as follows:—

Tirydail Colliery.

	Yds.	Ft.	In.
6. Coal at mouth of slant; supposed Cwmffaldau Vein	–	–	–
Shales, with a sandstone at bottom	40	0	0
5. Coal, supposed Stanllyd, unworkable	–	–	–
Shales, grey and black alternating	30	0	0
4. Coal, thin, formerly slightly worked; supposed Upper Triquart Vein	–	–	–
Shales	5	0	0
3. Coal, supposed Charcoal Vein	–	2	6
Shales with a 3-foot band of sandstone	11	0	0
2. Coal worked (Lower Pumpquart Vein)	–	3	2
Shales with fireclay and a 4-foot sandstone	9	0	0
1. Coal	–	1	6

Before attempting to correlate these veins with others in the district we must examine the section of the Park Colliery shaft, which is as follows:—

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* Information from Mr. Geo. Roblings.

Park Colliery.

		Depth. Ft.	In.	Suggested equivalent.
8.	Stanllyd Vein (thin)	44	0	Stanllyd.
7.	Middle Pumpquart Vein	63	10	Middle Pumpquart.
6.	Upper Triquart Vein	89	2	Upper Triquart.
5.	Charcoal Vein	125	4	Charcoal.
4.	Vein, 2 ft. 8 in.	230	8	Brasslyd.
3.	Vein: Coal, 2 ft 6 in.; Clod, 1 ft.; Coal, 8 in.	321	11	Gwendraeth.
	Vein, 1 ft.	329	0	
2.	Vein, 1 ft.	369	0	Lower Triquart.
	Vein, 2 ft.	379	0	
1.	Lower Pumpquart Vein	395	0	Lower Pumpquart

Here the supposed Lower Pumpquart contains lamellibranchs (probably *Carbonicola*) as at other collieries in the district. The supposed Lower Triquart and Gwendraeth Veins are doubtful, the coals so identified being double, but they roughly correspond in position with those veins. The higher veins are more probably correctly identified. There is a bed of sandstone 28 feet thick at a depth of 165 feet.

Comparing the Tirydail section with this, it will be found that if the so-called Cwmffaldau Vein of Tirydail be regarded as the Charcoal of Park, the other veins roughly correspond in position, group for group, which leads us to the following correlation:—Tirydail No. 6 is the Charcoal; No. 5 is the Brasslyd; No. 4 is the Gwendraeth; No. 3 is the Lower Triquart; No. 2 is the Lower Pumpquart; No. 1 is possibly a vein which in the Gwendraeth Valley is said to lie some 8 or 9 yards below the Lower Pumpquart and to have this thickness.

Returning now to our description of the veins at Pont Lash, we find that from that point they run about west-south-west between the Lash and the Llandybie-Penygroes road, along the north side of which there are several old pits to the Stanllyd between Waunbôth and Blaenau-bâch, at which latter place the vein is said to be 30 to 35 yards deep. The crops lie some way to the north and are said to cross a brook just west of Blaenau, where there are numerous old pits to the Stanllyd. The Upper Triquart is believed to crop in the Lash at the bend 200 yards west of Blaenau Mill, and a sandstone quarry is presumably in the rock above the vein; the sandstone is rolled up again at the mill. Thence the vein runs westwards along the north side of Cwm-côch, and there are old workings on it 200 yards north-west of Blaenau. A smut, probably the crop of the same vein, is visible in the road east of Derwen, while at that farm itself there is an old level in the vein; the coal is visible, and is about 2 ft. 10 in. thick; above it is a sandstone; the dip is a little west of south at 26°. At Cwm-côch house there must be a syncline, for south of the brook the beds rise to the south, and about 200 yards west of the house there is an old slope on the Upper Triquart.

Reverting to the Stanllyd Vein, which we left just west of Blaenau, we find a number of old pits to it along the Llandybie-Penygroes road at Cwm-côch school. The crop probably passes under the school. Here the air-shaft to the present Cae'r-bryn Colliery is said to be 50 yards to the Stanllyd. West of the school the crop continues along the north side of the road, with southerly dip, but presumably rolls over to the north again at Cae'r-bryn Farm. There are some old pits and patches, probably on the Stanllyd and Middle Pumpquart, between that and Plâs-gwyn in which the beds dip about north-west, and a pit to these veins is situated 100 yards east of the last-named farm. Here the crops turn round and strike south-westwards, with south-easterly dip.

At Bryn-y-fuwch, north of Pen-y-groes, a sandstone comes in above the Stanllyd and persists westward as far as the old Gilfach Colliery. There are two old pits to the vein below it in Bryn-y-fuwch farmyard, and a little pit 100 yards east-north-east of the farm and begun just below the base of the Stanllyd rock is said to have got the Middle Pumpquart at eight yards. West of Bryn-y-fuwch an old level on the escarpment, below the Stanllyd rock, is said to be on the Middle Pumpquart, and 70 yards farther on, and a little higher up the scarp, the Stanllyd rock has been quarried.

The old Gilfach Colliery had a slope on the Stanllyd, on or near the crop, and a pit to the vein. The Middle Pumpquart also was worked. The beds were found to be affected by the rolls visible in the Big Vein at Emlyn. The old Gors-gôch Colliery shaft commenced just below the crop of the Big Vein, and was sunk to the Charcoal Vein at 120 yards. The colliery worked the Stanllyd, Gras-uchaf, Gras-isaf and Charcoal Veins, and also the Lower Triquart, which was reached by a long cross-measure drift in a north-west direction from the shaft at a depth of about 84 yards (between the Gras-uchaf and Gras-isaf wing), and crossed the veins in succession to the Lower Triquart (some say the Lower Pumpquart). The Lower Triquart was struck at about 77 yards depth in a shaft by the side of the Cross Hands road at 200 yards from Gors-lâs; the Gwendraeth was struck in the same shaft at 48 yards. The Lower Triquart would reach the surface under the Gwendraeth river in front of the Union Inn.

The dip in the cross-measure drift was about 23° or 25°. Between the Lower Triquart and Lower Pumpquart are numerous balls and pins of mine.

At the old Cross Hands Colliery there were two slopes, one on the Big, the other on the Stanllyd, and the Green Vein is about to be opened. The veins worked were the Big, the Stanllyd, and the Middle Pumpquart.

We have now to return to the veins above the Stanllyd, viz., the Bwla, the Cwmffaldau, the Green or Upper Pumpquart, the Little or Yard Vein, and the New, Rock, or Big Vein.

South of the Pontyclerc Thrust.—At Pontyclerc, south of the Pontyclerc Overthrust, a group of veins crops out which includes the Rock Vein and others down to what is known as the Lower Fireclay Vein, which may be taken to correspond to the Upper Triquart or Gras-isaf. The veins were worked by shafts and slopes at the old Pantyffynnon Colliery, and also at the old Pontyclerc Colliery east of the Loughor and opposite the present Pontyclerc Brickworks. The present Pantyffynnon Colliery is again opening up the veins by a drift.

At the old Pontyclerc Colliery there were two drifts sunk to the deep which descended through the measures and struck a vein called the Yard Vein, 2 feet 9 inches thick, which was to some extent worked. A shaft 150 yards south of the drifts was sunk 50 yards and bored another 12 yards to the same vein. It passed through three higher veins, respectively 3 feet 6 inches, 3 feet, and 3 feet 9 inches in thickness, which appear to be the Rock, Middle, and Upper Pumpquart Veins, all of which would crop between the drifts and the shaft. The Yard Vein which appears to be the Rocket Vein would crop 50 yards north of the drifts. The veins dip at 1 in 3 (19°).

Between these workings and the outcrops of the same veins at Pontyclerc Brickworks there is said to be a north-north-west fault with a downthrow east, supposed 17 yards.

West of the Loughor the Rock and other veins crop out on the side of the valley and there are numerous old workings on them; several of the crops can be located exactly. At the Pontyclerc Brickworks the fireclays underlying two thin veins called the Fireclay Veins are being worked; and the coals were well-exposed (in 1901) in the pit. The upper vein was 1 foot 3 inches to 1 foot 5 inches thick, and the lower 8 inches thick, with 30 feet of measures between.

The old Pantyffynnon Colliery balance-pit, about 130 yards north-west of the road-bridge over the Loughor, passed through the Rock Vein at 103 yards, and is said to have continued to the Stanllyd at 203 yards. The Rock and Upper Pumpquart were the veins principally worked. In the former the dip averaged about 2 feet per yard. In more recent years the Rocket Vein has been worked from slopes on the crop. The Stanllyd Vein though 4 feet 6 inches thick is unworkable. The new Pantyffynnon drift lately put down by the Park and Blaenau Company starts below the crop of the Upper Pumpquart and ascends in the measures, the dip of which is in places 27 inches per yard.

Little is known about the ground below the Fireclay Veins. An old shaft north of the brickpit started at the crop of the Lower Fireclay Vein and went down 80 yards, but no records are extant. The highest beds would be the sandstone once quarried a few yards to the north, and exposed at Pontyclerc Farm and at the bridge itself. Below the sandstone which makes a steep bank along the south side of Fferrws Brook Mr. Lloyd* sank a trial-pit on the south side of a pool; the section was as follows :—

	Ft.	In.
Measures - - - - - - - - -	18	0
Coal - - - - - - - - - - -	2	0
Measures, chiefly shales with mine, and some rock	78	0
Coal, (bored to) - - - - - - - -	3	6

These two coals may possibly represent the Charcoal and Gwendraeth Veins.

The outcrops of the Pontyclerc veins may be followed westwards towards Ty-croes. Here, at Wern-nôs, the Rhôs Colliery Company have recently driven a cross-measure drift in a south-westerly direction for the purpose of getting the Upper Pumpquart and higher veins under Mynydd-bâch. The drift starts a few feet below the crop of the Stanllyd which is visible a few yards down the drift, and beyond this the Bwla Vein was cut. A little old pit at Cae-helyg is said to have been to the Upper Pumpquart, and the Little and New Veins may crop higher up towards the south-west, where there are old workings. The Logan MS. states that on Mynydd-bâch there are three veins of coal :—

	Ft.
Coal - - - -	3½ to 4
Measures - - -	60
Coal - - - -	2½
Measures - - -	30
Coal - - - -	4

These correspond very well in relative positions and thicknesses with the New, the Little, and the Upper Pumpquart Veins of Rhôs.

The Rhôs Company have recently sunk a trial-shaft to a depth of 103 yards on Mynydd-bâch, and at a distance of 200 yards south-south-west of Cae-helyg. It passed through several coals the correlation of which is uncertain, but one of which, at 33 yards depth, is possibly the Upper Pumpquart. From the bottom of the shaft a drift, cut in an east-south-east direction for about 180 yards, passed through several coals, the last of which may be the Middle Pumpquart. If this be so there must be an upthrow south somewhere in the drift of at least 40 yards. But the greater disturbance lies apparently north of the shaft. If the dip of the Stanllyd and Middle Pumpquart Veins at Rhôs be continued southwards the Middle Pumpquart Vein would lie over 100 yards below the bottom of the trial-shaft, whereas it ought to occur 76 yards below the Upper Pumpquart or a little below the bottom of the shaft, so that we have evidence of a further upthrow south of over 100 yards.

The course on the surface of these overthrusts is only indicated in a general way by the course of the outcrops of the coals; along Fferrws Brook there is no exposure of the disturbance, but the most southerly Stanllyd workings from Park and also from Rhôs have ended in disturbed ground which practically follows the course of the brook. Mr. E. R. Fisher states that the face of the thrust where he saw it near the bottom of the main slant in the Park workings was nearly vertical. An approximate estimate of the throw of the disturbance at Wern-nôs can be formed on the following evidence. The Park Colliery's main slope on the Stanllyd ends on the north side of the disturbance at about 150 yards vertically below the surface. On the other side, the crop of the Stanllyd at Wern-nôs, if prolonged northwards to reach the disturbance, would be about 50 yards above the surface. Hence the northerly downthrow due to the disturbance must amount to about 200 yards.

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* To whom we are indebted for information on the Pontyclerc District.

Farther east, at Hillside, on the hill at Pontyclerc, Mr. Lloyd many years ago sank a pit 20 yards deep in a nearly vertical coal supposed to be the Upper Pumpquart, to which there are numerous old pits west of Pen-y-banc close by. On the other hand, no disturbance was encountered in the Stanllyd workings from the old Park Colliery for a distance of 240 yards south-east from the shaft. The disturbance therefore must lie between the old Park workings and the Pontyclerc sandstone, and may be taken as passing through the pit at Hillside. West of Wern-nôs the veins are presumably cut off along Fferrws Brook by the overthrust.

North of the Pontyclerc Thrust.—Crossing now to the north side of the thrust and tracing the veins above the Stanllyd we have the section of the Rhôs winding pit which commenced 10 yards above the New Vein and reached the Upper Triquart or Gras-isaf at a depth of 129 yards. The following is a section * of the shaft at Rhôs Colliery :—

	Thickness.		Depth.		
	Ft.	In.	Yds.	Ft.	In.
Measures					
New Vein	3	6	10	0	10
Measures					
Little Vein	2	6	32	0	10
Measures					
Upper Pumpquart Vein	3	4	42	0	2
Measures					
Cwmffaldau Vein	3	0	69	1	7
Measures					
Bwla Vein		9	89	0	5
Measures					
Stanllyd Vein	3	10	103	1	0
Measures					
Middle Pumpquart Vein	3	0	118	1	0
Measures					
Upper Triquart Vein	2	4	129	1	0

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* Communicated by Mr. David Davies, manager.

The Stanllyd and the Gras-isaf are the veins chiefly worked. The Bwla Vein is only 9 inches thick and in places less; the Cwmffaldau is impersistent, and though in places 3 feet thick is generally soft and of little value. The Upper Pumpquart or Green Vein appears to crop west of Pen-y-banc, and is probably the vein once worked on the crop at Nant-y-ci, and also that which crops in a brook near Gwaun-rhedegfa, at Saron. North of this spot it is probably cut off by the disturbed ground proved north of the Park Pit.

The old Hendre Colliery worked the New or Rock Vein, and probably the Little and Upper Pumpquart also. An old pit at the back of Hendre College is said to have got the New Vein at 40 yards and the Upper Pumpquart at 70.

The rock above the New or Rock Vein is seen in the brook at Rhôs Colliery and has been quarried by the brook side at Hendre-Siclath, where it consists of irregularly-bedded hard grey sandstone alternating with shales-with-mine. About 80 yards above the farm last named a coal, presumably the Rock Vein, crops in the brook, and there are old pits on it at Heol Collier, where the overlying rock has been quarried. Thence the rock, with occasional little pits to the coal, can be followed towards Blaenau-mawr, where, on a path at 200 yards east of the house, it dips about north-north-west at 40°.

The rock reappears between Malta and Lletty-gwyn with a south-easterly dip, and is separated from the outcrop near Blaenau-mawr probably by a fault, which it is not unlikely is connected with that proved at Park. Thence to Cae'r-bryn its outcrop, which is easily traced by numerous natural and artificial exposures, describes a series of sigmoidal curves produced by repeated anticlines and synclines. Between Malta and Lletty-gwyn there are old pits to the Rock Vein, which is 3 feet thick. Between Lletty-gwyn and Cil-rhedyn a roadside quarry in the Rock Vein rock shows irregularly-bedded blue fine-grained sandstone with shale-partings, overlain by shales which appear to have been thrust over the sandstone from the south. The rock is again excellently exposed at Maes-glâs. On the south side of the valley at Cae'r-bryn Colliery this same rock has been quarried, and just below is a drift to the coal. To the east of Cottage Hall in Logan's time (1838) there was a pit of 6 fathoms which was wholly in this sandstone; the vein is stated to have been 3 feet thick and to have dipped at 18 inches per yard.

At Cae'r-bryn Colliery the shaft begins in the rock above the Rock Vein and goes down to the Middle Pumpquart; the veins worked being the Green, the Stanllyd, and the Middle Pumpquart. The Green Vein is about 25 yards below the Rock Vein rock. The distance between the Rock and Yard Veins at Cae'r-bryn Colliery is said to be 12 yards; but between there and Pen-y-groes it was recorded by Logan and is generally accepted that the whole of this thickness disappears; the resulting vein being thence westwards known as the Big Vein, or Gwendraeth Big Vein, to distinguish it from the Stanllyd or Cwm Amman Big Vein.

At Carn-llwyd, south of Bryn-beddau, a fine white quartzite is brought up as an inlier on the crest of a small anticline; it is presumably the Rock Vein rock. Between it and Maes-glâs a rock of similar character appears to form an outlier; this must be at a higher horizon and may be the same bed as has been quarried on the west side of the Hendre Fault 400 yards south-west of Bryn-beddau.

At Pen-y-groes this fault, a north and south fracture with westerly downthrow, divides the Cae'r-bryn district on the east from the Emlyn ground on the west. Farther south the fault was reached at Hendre in the Stanllyd workings from Rhôs Colliery, where it is commonly reported to have a throw of 90 or 100 yards, but this figure has not been proved and it is certainly much less at Pen-y-groes. In the easternmost of the Emlyn workings a fault throws the Stanllyd ground against the Upper Triquart ground, and is about 21 yards down west; but it is doubtful if this fault is more than a branch of the larger disturbance. A fracture apparently down west, and slickensided, is visible in some shales in the roadside 250 yards from Pen-y-groes on the Llandybie road; and the fault accounts for the spring utilised in the public well on the opposite side of the road. This may be the main line of fault; it would not well join up to that proved from the Emlyn workings. Northwards its effects are not traceable and it certainly does not cut the Farewell Rock.

West of this fault the Big Vein, consisting of the combined Rock and Yard Veins, was formerly worked over a large area south of the peat-bog at Pen-y-groes, where it lay near the surface in the core of an anticline surrounded by an elliptical outcrop of the superjacent rock. The rock is exposed at the end of the lane 150 yards south-east of the railway-bridge at Pen-y-groes; and has been quarried at Gors-ddu and again a little west of Emlyn Colliery air-shaft. It seems to be more or less replaced by shale where it crosses the railway, but a little way along the Llandybie road, east of Pen-y-groes cross-roads, it is again well-exposed on the axis of a syncline. A little farther north it is traversed by an overthrust fault having a direction about W. 20° S. which was encountered farther west (and may still be seen) in the old California slope. The thrust, which is vertical, has the effect of a downthrow north of at least 45 yards. The result of the fault is to widen the outcrop of the Big Vein rock and carry its northern margin farther north than it would otherwise be; at the same time the bed is thrown into an anticline and syncline. The old 'Mary' Pit on the west side of the road to Bryn-y-fuwch from Pen-y-groes got the Big Vein at 28 yards and was on the axis of the syncline; and another old pit a little farther north (opposite the road to Cwm-côch) passed through the Big and Green Veins, and reached the Stanllyd at 27 to 28 yards. The Big Vein rock has been quarried 100 yards north of the California slope, but south-westwards is soon cut off by the thrust. South of the thrust it has been quarried again 150 yards east of Ty-newydd, and a few yards north of it the outcrop of the Big Vein is marked by holes as far as the peat-bog west of the Gilfach Colliery. The Big Vein at California Colliery is 8 feet 6 inches thick, but was rather inferior in quality.

The present Emlyn Colliery * works the Stanllyd and Middle Pumpquart Veins, and to some extent the Upper Triquart also, by a drift commencing near the top of the Big Vein rock and descending across the measures southwards. The air-shaft was begun on the top of an anticline, just below the crop of the Big Vein, and goes down to the Charcoal Vein, at a depth of about 117 yards. The section of the Stanllyd Vein is given as follows :—

Stanllyd Vein, Emlyn Colliery.

	Ft.	In.
Clift, good roof	—	—
Shaly clod	3	2
Soft coal, mixed with fireclay	1	0
Coal		9
Coal	3	6
Clod		3
Bastard Fireclay, floor	—	—

Another section of the Stanllyd Vein is given as follows :—

Stanllyd Vein, Emlyn Colliery.

	Ft.	In.
Grey clift top	—	—
Borden Fâch, 9 ins. to	1	0
Borden Fawr		9
Borden Fâch, 2 ins. to		4
Coal, 4 ft. 6 in. to	5	0
Underclay	—	—

The Big Vein section is as follows :—

Big Vein, Emlyn Colliery.

	Ft.	In.
Rashes	2	0
Top coal	3	6
Clod, 6 ins. to	1	6
Coal	1	0
Clod, 6 ins. to	1	6
Bottom coal, 2 ft. 6 in. to	2	10

The Middle Pumpquart Vein is said to present the following details :—

Middle Pumpquart Vein, Emlyn Colliery.

	Ft.	In.
Clift quar (black clift)	—	—
Clod, comes down with the coal		4
Coal, 3 ft. to	3	6
Underclay	—	—

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* Information from Mr. H. F. May.

West of the Gors-lâs peat-bog the Big Vein reappears at Gors-gôch where the crop can be traced by old sinks and pits. The old Gors-gôch Colliery has been already described (p. 125); the shaft began 2 yards above the Green Vein. A fireclay obtained from below one of the coals was used for firebricks. The Big Vein was worked by a slope at the old Cross Hands Colliery; and the vein is supposed to crop under the road at the Cross Hands Inn, beyond which it is cut off by the Bryn-gwili Fault.

Above this group of coals follows a thick series of shales and subordinate sandstones which should contain the Red Vein; but west of the Bettws Fault this coal is unknown. At Ammanford a clod 5 feet thick divides the vein into two parts, the lower of which was worked at the Dynevor and Maes-y-cwarau Colliery as far west as the Bettws Fault, but beyond that the vein has never been recognised.

At Argoed-fawr, south-east of Bettws, a well-marked band of cockshot rock lies about 100 or 120 yards above the Red Vein. What is probably the same rock crops out west of the Loughor at Gellicaedrim and Pen-yr-heol, south of Ty-croes, where it contains coal-fragments (p. 93), and the calculated position of the Red Vein lies somewhere near Pen-y-garn, where there are some old cropworks on the south side of the brook opposite Clyscwm; but these, though said to have been on a coal, may have been on a band of mine.

At Clawdd-du the cockshot rock is thrown down west by the Hendre Fault and crops out south of Greynor, so that the Red Vein horizon may be assumed to crop somewhere between that place and Gelli-beraidd. In fact there are several old pits by the brook-side a quarter of a mile west of Greynor-isaf which are said to have got a bad coal 2½ feet thick, and a coal-smut may be seen in the road hard by.

At Cefn-gwili the measures are again thrown down west by the Glyn-Wallis Fault, and the Red Vein horizon must be carried down under the boulder-clay of the Gwili Valley, where there is no chance of seeing it.

Above the cockshot rock thick sandstones alternating with shales set in, and may be seen in the dingles west of Plâs-mawr, also west of Clawdd-du, and south of Cefn-gwili, where they contain a thin coal. Though not included in the Pennant Series, they closely resemble that rock.

T. C. C.

Though much obscured by drift, enough of the upper part of the lower series is exposed to show that it includes some thick sandstones corresponding to the Llynfi Rock of the Maesteg district.

Shales and sandstones of this series are exposed in a dingle above Erw-wastad-fawr, but, whereas those near the farm belong to a horizon at some distance from the top, those higher upstream immediately underlie the Pennant and are separated from the preceding by the Hendre Fault (p. 178). Both east and west of the fault a mass of Pennant-like sandstones underlies shales. The sandstones to the west have been quarried at Dyffryn and form a bold feature running south-west by Bryn-y-rhyd, but there end abruptly against the Glyn-Wallis Fault (p. 178).

The shales above these sandstones are about 70 yards thick, and underlie a vein which has been worked at Gelli-organ and elsewhere. This, as we shall see, probably represents the Ynysarwed (No. 2 Rhondda) Vein, *i.e.*, the base of the Pennant Series. The shale contains pins and balls of mine which in the upper part appear to have been worked east of Dyffryn, and higher still a thin shale-bed is crowded with shells (E. D. 231) recognised by Mr. W. Gibson as probably *Anthracomya phillipsi*, Will., a form he has found on the horizon of No. 1 Rhondda Vein on Resolven Mountain, but never below No. 2 Rhondda.* This evidence, such as it is, supports the identification, made on stratigraphical evidence, of the No. 2 Rhondda Vein at Dyffryn.

West of the Glyn-Wallis Fault, which at Pentre-hardd has a considerable downthrow to the west, the cockshot rock and higher beds are exposed along the Gwili between Dingle and a dingle south of Plâs-newydd. The lowest band of cockshot rock is seen passing up into shale in a river-cliff at Dingle. A higher band exposed 160 yards to the south-east is speckled with particles of coal similar to those noticed elsewhere at about the same horizon by Mr. T. C. Cantrill (pp. 93, 132).

This cockshot is succeeded by a group of less quartzitic sandstones with shales, the former exactly like those of the Pennant Series. The sandstones are well exposed at Plâs-newydd Mill in the banks of the Gwili. At the top of this group is a coal which lies about 1,350 feet above the base of the cockshot rock and which approximately corresponds, therefore, to the Gelli-organ vein mentioned above, the base of the Pennant Series.

E. E. L. D.

From the Bryn-gwili Fault to the Tumble Fault.

At Cross Hands the measures are cut by a large downthrow west, which passes under Bryn-gwili House and ranges in a south-south-east direction towards Pontardulais. The fault has a marked effect on the form of the ground, separating as it does the soft measures associated with the Big and other veins on the east from the sandstone-country on the west.

The fault has not been proved by underground workings, but a fault with easterly hade—probably a minor parallel fracture—was touched in the Lower Pumpquart workings from New Cross Hands Colliery.

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* In 'The Country around Merthyr Tydfil,' 1904, p. 78, *Mem. Geol. Surv.*

The Bryn-gwili Fault shifts the outcrops northwards on its west side, and the Lower Pumpquart and Lower Triquart Veins re-appear near Foel Gastell. The former may be identified in a poor coal, 3 feet thick including partings, which crops out in the stream at Craig-y-geifr, immediately west of the fault; and the coal has been got by old shafts and slopes farther west near the Dynevor Lodge Inn, and along Cwm-cae-helyg Brook. The Logan MS. records that the coal was 4 feet thick, and that towards Maes-y-cwd it was cut out by the roof and floor coming together.

There are signs of a higher vein having been worked along the south side of the brook half-a-mile north-east of Parc-Dai Bridge; and still higher measures, exposed in the Gwendraeth-fawr below Pont-Trefenty, contain some coals which have been to some extent worked. The veins from the Gras-isaf to the Big should crop between the river Gwendraeth-fawr and the Mynydd Mawr Railway, but nothing is known of them.

The Red Vein is unknown as such west of the Bettws Fault, but may be represented by a small vein which lies about 100 yards below the cockshot-rock and has been worked on the crop 500 yards south-west of Llech-y-fedach. Near Pontyberem (about 3 miles to the south-west) a vein known as the Carway-fawr (p. 92) appears at about the same general position in the Coal Measures, but it may be as much as 100 yards lower.

The cockshot-rock itself forms a striking feature at the top of the scarp east of Tumble, and is exposed in some crags and quarries traceable from Pant-gwyn at Cross Hands as far as Tumble, where it is thrown south by the Tumble Fault. It forms the base of a group, about 1,000 feet thick, of sandstones and shales, containing some thin and impersistent coals, the whole corresponding in position to the Llynfi Rock of other parts of the coalfield.* The 'cockshot' of Maesteg lies about 350 or 400 yards below the No. 2 Rhondda or Rock Fawr Seam of that neighbourhood † and thus, at first sight, seems to correspond; but the 'cockshot' of the North Crop lies at least 400 yards above the Stanllyd, whereas the 'cockshot' of Maesteg lies about 130 yards above the Nine-foot Seam, which is approximately correlative with the Stanllyd.

The alternation of hard and soft strata gives rise to the ridges and hollows between Cross Hands and Tumble, and the outlier at Blaenau, a mile south of Cross Hands, belongs to one of these beds of sandstone. What is probably the same band of cockshot rock reappears farther south, on the west side of the Bryn-gwili Fault, at Gelli'r-odyn, one and a half miles south of Cross Hands; and whether this be the same band or not it will be seen on an inspection of the map that the distance between the cockshot outcrop at Cross Hands and the base of the Pennant south of Gelli'r-odyn is much greater than it should be. We are thus compelled to assume that a considerable downthrow north crosses this ground. There is evidence of such a fault in the Gwili river at Cwm-uchaf, three-quarters of a mile below Cross Hands, where it takes the form of a belt of steeply-dipping beds, the strike of which trends thence in a south-south-west direction along a well-marked hollow to beyond Blaenau-mawr, and separates the shale-ground below the cockshot rock of Gelli'r-odyn on the south-east from the sandstone ground of Bryn-mawr and Pen-twyn on the north-west.

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* R. H. Tiddeman in 'The Country around Pontypridd and Maestêg,' 1903, p. 30, *Mem. Geol. Surv.*

† Vert. Sections of the Geol. Survey, Sheet 85, Sections 7 to 12.

The Gelli'r-odyn cockshot-band is succeeded by sandstones with shales, exposed in a dingle west of Rhyd-sarnau and towards Dyrclawdd.

T. C. C.

These beds in the district to the south-west nearer Llannon are poorly exposed and are both folded and faulted. Some information about them, however, has been obtained from a boring about half a mile east-north-east of Llannon, for an account of which we are indebted to Messrs. Foster Brown and Rees. The boring, after passing through 865 feet of sandstones with subordinate shales, traversed strata in which shales so far predominated as to show that they must belong to the Lower Coal Series. Assuming, therefore, that the sandstones corresponded to the Llynfi Rock, the upper part of that series, which, south and east of Tumble, is about 1,000 feet thick (p. 134), we infer that the boring started at least 150 feet below the base of the Pennant. Against this view it may be remarked that a coal was proved at a depth of 272 feet which resembles the No. 2 Rhondda Vein as identified at Pen-llwyn (p. 159) in that its thickness is 2 feet 7 inches and that it contains a parting of shale 4 inches thick, but we do not believe that it is the same vein, on account of there being only 593 feet of sandstones below it.

E. E. L. D.

From the Tumble Fault westwards.

At Tumble the measures are cut by the Tumble Fault, a downthrow east of some 200 yards ranging southwards towards Llannon and northwards to the Carboniferous Limestone at Foel Gastell. On the west side of the fault the Lower Pumpquart and Lower Triquart Veins were worked at their crop at the old Cwm-mawr or Parc-Dai Colliery, where the Lower Pumpquart workings touched what was probably the Tumble Fault. At the Clôs-yr-yn Colliery, reopened in 1903, the Lower Pumpquart was worked by a slope situated on the crest of a sharp anticline, by which it is rolled down steeply northwards. It was next worked by shallow pits on the north bank of the stream a quarter of a mile below Parc-Dai Bridge, and by deeper pits and slants on the crop north-east of Cwm-mawr, at one of which the Lower Triquart was gained by a cross-cut from the Lower Pumpquart. The old Cwm-mawr shaft, 100 yards below the Gwendraeth bridge, got the Lower Pumpquart at 52 yards. In 1903 the vein, with a thickness of 3 feet 4 inches, was being worked at the New Cwm-mawr colliery by slopes, the vein dipping south-east at 14½ inches per yard. A little farther to the south-west it is thrown northwards by the Dynant or Clôs-isaf Fault, a westerly downthrow which extends from the Carboniferous Limestone in a south-south-easterly direction towards Llannon. A fault was touched under Hirwaun-isaf in the Lower Pumpquart workings from Clyn-hebog.

Of the next higher veins from the Gwendraeth to the Ddugaled, little is known between the Tumble and the Dynant Faults; the Gwendraeth, 2 feet 10 inches thick, was being worked on the crop in 1902 at the New Dynant or Rhyd-y-cerig slopes; the coal was visible in the slope, and had a dip towards the south-east of 10 or 12 inches per yard; under the air-pit it jumps up 4 or 5 feet on the south-east by a small thrust or fold. Between this point and the old Dynant Colliery there are numerous old pits and drifts probably to the Brasslyd and higher veins, but no reliable information could be obtained. At Dynant-fawr there are old pits, said to have been sunk to the Ddugaled and Gras veins.

The crops of the Green and Big Veins are better known. At Tumble the Great Mountain Colliery works the Big and Green Veins by a slope in the latter, and the workings extend as far as the Tumble Fault, which was touched in the easternmost workings. Some rolls in the veins were proved north-west of Ty'n-ton. From the Great Mountain slope the crops extend westwards under the Tumble Inn, and can be traced thence by crop-works to Dyffryn-araul, where there are old pits 25 or 30 yards deep to the Big Vein. At the old Tumble Colliery hard by there were shafts to the Big Vein and a slope on the Green Vein; the Gras (-uchaf ?) also was got by a cross-cut, and is supposed to crop out in the field behind Bethesda Chapel. The Big Vein workings proved some rolls west of Ty-isaf. The crops of the supposed Gras (-uchaf ?) and Ddugaled Veins are visible in the brook south of Maes-Gwenllian.

From the old Tumble Colliery the Green and Big Veins can be traced by old crop-pits and slopes to the old Dynant Colliery, where there was a shaft to the Gras (-uchaf ?) Vein and a slope on the Green Vein. Here the veins are thrown northwards by the Dynant or Clôs-isaf Fault, which was touched in the Green and Big Vein workings.

Between the Big Vein and the cockshot rock there is a considerable thickness of barren measures, chiefly shale, which contain nothing more than one or two thin smuts. At Coedcae a small vein is exposed in the brook and may be one of the Felen Veins of the Pont Henry district (Sheet 229). Two other small veins are exposed in an old lane 250 yards north-west of Lletty-mawr, and there are three coals, 5 inches, 6 inches, and 1 foot thick respectively, in a brook 300 yards south-west of Coedcae.

In the upper part of this barren ground there are several outcrops of cockshot rock, as at Garn-fâch and Park. They strike south-eastwards, at right angles to the main cockshot outcrop which runs continuously along the top of the scarp from Lletty-mawr, south of Tumble, in a south-westerly direction for over a mile; and whether they are identical with the chief cockshot band, or belong to a somewhat lower horizon, as is more likely, they are probably cut off on the south-east by a strike-fault parallel to the main escarpment. Their abnormal direction is probably due to the same causes as have produced the rolling proved in the Big and Green Veins alluded to above (p. 136).

The main cockshot band itself makes a very conspicuous feature, and the rock is frequently exposed from Lletty-mawr south-westwards as far as the Dynant Fault south of Pen-llwyn-gwyddau. It forms the base of a group of alternating sandstones and shales, about 1,000 feet thick as at Tumble (p. 134) which occupy some peaty and moorland ground between Tumble and Llannon; some of the sandstones are in places quartzitic, as may be seen in the Morlais Valley near Pen-y-cwm-uchaf. These beds are followed by the Pennant series of Llannon.

West of the Dynant Fault, in the Pontyberem district, one or two thin coals make their appearance between the Farewell Rock and the Lower Pumpquart Vein. At 350 yards west of the present Clyn-hebog Colliery an old drift reached a thin coal which must lie about 70 yards below the Lower Pumpquart and corresponds in position to the Rhâs-fâch Vein, the lowest known coal in the Pont Henry district. An old drift on the north side of the Gwendraeth-fawr, one-third of a mile west of Maes-mawr, was made in search of the Rhâs-fâch mine, but was unsuccessful, though the bottom stone and traces of the coal were found.

The Lower Pumpquart Vein west of the Dynant Fault was worked a little by a small pit on the west side of a brook a quarter of a mile north-north-west of Clôs-isaf; from this pit the crop runs south-westwards to the old Clyn-hebog slopes, where the coal averaged 3 feet 9 inches thick, and dips about south-south-east at 18½°. An easterly downthrow of some 11 yards runs parallel to the slopes. South-west of this point the vein is now worked at the present Clyn-hebog slopes of the Pontyberem Collieries Co.; the vein dips at 18½°, increasing southwards to 22°. At 100 yards south of Groes-faen the main slope met with a small syncline followed on the south-east by an anticline, causing the vein to rise some 20 feet, beyond which the coal locally thinned out owing to the contact of roof and floor.

The Pontyberem old colliery worked all the veins from the Lower Pumpquart to the Big Vein by two shafts: the Gwendraeth Pit on the north commenced just above the Gras-uchaf Vein and at 145 yards reached the Lower Pumpquart; the South Pit began well above the Big Vein and was sunk 88 yards to the Ddugaled Vein, and a cross-measure drift was cut northwards from the one pit to the other through the Hwch to the Gwendraeth Vein. All the veins were thus proved; there were also slopes on the crop of the Ddugaled Vein.

The present colliery is nearly half-a-mile north-east of the old one, and the coal is got by a full-dip slope on the Green Vein, with a dip of about 8 inches per yard. The Big and Gras-uchaf also are got by cross-cuts from the Green Vein.

Near Pontyberem old colliery the outcrop of the Lower Pumpquart Vein probably runs under the alluvium of the Gwendraeth River, where there was a pit 28 yards deep to the vein; the ground around the pit subsequently collapsed, and the site is now covered with slag-hillocks.

The Triquart Vein averages 2 feet in thickness, but is not now worked west of Cross Hands, and in the neighbourhood of Pontyberem little is known of it. The succeeding veins were all more or less worked, but little is known of their crops, except in the case of the Green and Big Veins, along which old crop-works and slopes are traceable between Groes-faen and Pontyberem.

A north-and-south fault with easterly downthrow of about 17 yards in the Lower Pumpquart and 16 yards in the Gras-uchaf was proved in the old Pontyberem workings; it runs about 70 yards east of the South Pit. There seems also to be a north-north-westerly fault in the Big Vein about 100 yards west of Lletty-wilws south of Dynant, and although the throw is supposed to be 55 yards down west, its surface position is uncertain.

Above the Big Vein should follow the two Felen Veins and the two Carway Veins, but they do not appear to have been proved east of Pontyberem, with the exception of the supposed Felen Vein at Coedcae (p. 136). One or two thin veins and bands of ironstone still higher have been got by little pits at Cwm and Coedmawr.

The cockshot rock which introduces the Llynfi Rock group of sandstones and shales, when it reaches the Dynant Fault, shows signs of beginning to die out. It is presumably shifted northwards by the fault to Pen-llwyn-gwyddau, where it has been quarried. From this point it disappears for a space, but the same or a slightly lower band (estimated to lie at least 400 yards above the Big Vein) reappears at Cwm-blawd siding on the Llanelly and Mynydd Mawr Railway south-east of Pontyberem, but this again soon disappears. A somewhat higher bed is exposed in a dingle where crossed by the same railway north-west of Maen-gwyn. As elsewhere, the cockshot rocks are followed by alternating sandstones and shales, the former making conspicuous ridges and features between Bryn-gwnen and Disgwylfa. These beds contain one or two coals 1 to 2 feet thick, which have been worked at Bryn-banal-fawr, and occasional seams of blackband ironstone, one of which was tried by a level in the brook at Maen-gwyn.

T. C. C.

Small exposures west and south of Mynydd Sylen show that there, as elsewhere, a thick band of shale characterises the top of the Lower Coal Series. A boring put down near Coed-cyw-isaf 700 yards west of Tir-bryn proved a vein resembling the Brondini Vein at a depth of 469 feet underlain by 193 feet of shale. This thickness corresponds sufficiently well with the 150 feet of shale beneath the Brondini Vein at Brondini (Sheet 229). But although the boring proved a thick sandstone beneath the shale it was not carried down far enough to give any further check upon the correlation. Its position close to a fault adds to the uncertainty.

Inliers in the Llanedy and Llannon District.

Besides the foregoing exposures of the Lower Coal Series along its main outcrop, there are what we take to be inliers at Tre-neddyn, Efail-wen near Bryn-maen, and Cockpithall near Tir-bryn. In each case are seen poor exposures of merely the shales with fine-grained sandstones immediately below the Pennant Series, including at Efail-wen a band of red mottled fireclay.

Finally a coarse, strongly current-bedded sandstone quarried at Bryn-withan, is believed for the following reasons to belong to some horizon below the Pennant, though exactly similar lithologically to the sandstones of that series. It is separated by faults from south-easterly dipping beds on the east and from south-westerly dipping beds about Llwyn-teg chapel on the west, although its own dip is to the north or north-west. The faults together, however, do not greatly displace the base of the Pennant, and are, therefore, probably opposite in throw. There is no direct evidence as to downthrow, but we incline to regard them as directed away from one another, and the sandstones between them, consequently, as lower than the neighbouring Pennant series.

E. E. L. D.

CHAPTER IX.

CARBONIFEROUS ROCKS (*cont.*)

Coal Measures (*cont.*)—Pennant Series.

Introduction.

In the part of the coalfield lying west of the Glyn Corwg Fault (Sheet 248), the Pennant Series is separable into two main divisions. The lower, with the Ynysarwed or No. 2 Rhondda Seam at its base, includes the more massive sandstones; the upper, with the Wenallt or Hughes Vein at its base, contains almost as much shale as sandstone. The incoming of shales in this upper division is accompanied by the appearance of several valuable coal-seams, which have so far yielded the bulk of the coal worked in the Swansea and Llanelly districts. Shaft-sections of these measures showing the seams in their full development are given in Vertical Sections of the Geological Survey, Sheet 87, and will be discussed in the part of the Memoir descriptive of Sheet 247. The region now under description includes the northern portion only of the area occupied by this productive part of the Pennant Series.

It is to be remarked also that all these seams tend to thin away and even to disappear northwards and north-westwards. Thus the Ynysarwed Vein has proved scarcely worth working in the northern part of Farteg Hill, and is difficult to identify west of Cwm-y-gors; the Hughes or Wenallt has been worked under Mynydd March-Hywel, but was inferior at Craig-tre-branos and Llangiwg, while in Mynydd Bettws it is doubtfully identified as a mere smut. The Graigola or Six-feet Seam has been worked to its crop on Mynydd Garn-bâch, but has not repaid search made for it on the same latitude west of the Loughor. The Five-feet and Four-feet Seams of Swansea dwindle away still further south, and have neither of them been found worth working to their north crops. The area included in Sheet 230, therefore, includes the least valuable part only of the Swansea measures.

The existence of so great a mass of comparatively unproductive strata as is comprised in the Pennant Series and upper part of the Lower Series must have an important bearing on the future development of the coalfield. Its effect hitherto has been to divide the workings into (1) those of the Pennant and supra-Pennant seams of the Neath, Swansea, and Llanelly basins, and (2) those of the Lower Series on the north and south sides of those basins. In no one colliery are both worked, and attempts to reach the Lower Series in the deeper parts of the basin are only now under contemplation. Taking the Hughes Vein as the lowest of the upper group of seams, the distance to be sunk from it to the principal seams of the Lower Series would amount in the eastern part of Sheet 230 to little less than 1,000 yards. In the deeper parts of the basin the distance to be sunk from the Wernffraith, the highest of the more valuable seams, would amount in round numbers to 1,500 yards.

Dulais Valley to the Rhydding Fault.

The Ynysarwed Vein, which, in the belief that it represents No. 2 Rhondda Seam, we take as the base of the Pennant Series, is worked near Crynant (Sheet 231), with a thickness of 2 feet 10 inches.[*] It is supposed to crop in the Dulais close to Ynys Fadog, but is not visible nearer than Nant Merig, at a level south-west of Llwyn-on. Thence northwards there are old levels at frequent intervals, and one close to Llwyn-on shows 3 feet 6 inches of what is said to be steam-coal. At Crynant the vein is reported to be intermediate between a steam-coal and an anthracite.

One of the Ynys-ci faults with a downthrow west (p. 96) is commonly believed to cross Nant Merig 200 yards above the crop of the seam and to pass thence by Gelli-galed to the Dulais about 1,000 yards below Maes-yr-hendre. Here the existence of a fault with a downthrow west is indicated by the following evidence. No 1 Rhondda Seam, which was once worked at the Dulais Resolven Colliery, east of Crynant, is supposed to crop out in the banks of the Dulais 1,000 yards north-east of Glyn-y-bedd. Due east of that farm the Dulais Merthyr Colliery was started some years ago, and by sinking a shaft to a depth of eighty-seven yards, and boring a further distance of twenty yards, a coal was reached which was thought to be No. 1 Rhondda. The shaft is 600 yards distant from the crop in the river, nearly in the direction of full dip, and the seam might have been expected at forty or forty-five yards depth. From this it was inferred that a fault with a downthrow west of about sixty yards passes between the two, but no coal was ever raised from the shaft, and the identity of the seam both in it and in the river is open to doubt.

Some small seams crop out in the sides of Mynydd March-Hywel. One of them runs under Hendre'r-gynnen and is called the Stinking Vein; another which crops 200 yards south-west of that house shows 7½ inch of top coal and 14 inches of bottom coal with 8 inches of shale between. None of them are of any value. Among the Pennant sandstones there are occasional bands of a more purely quartzose grit, weathering into small blocks like Cockshot.

The upper part of Mynydd March-Hywel is formed by an outlier of the Hughes or Wenallt Vein, here known as the Gelliau Vein, with some shales above it. As far north as Tor-cefn the coal has been worked of recent years right through the hill, but north of that there are only old workings, the extent of which is unknown. The vein consisted of top coal 1 foot 10 inches, stone 10 inches to 1 foot 4 inches, and bottom coal 1 foot 9 inches. About thirty yards below the Gelliau Vein is the Little Vein, along the crop of which there are old levels, but which seems to have been less continuously worked. A level 550 yards north of Tor-cefn shows a shale-roof, coal 5 inches, shale 1 foot 8 inches, and bottom coal 2 feet 5 inches thick.

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[*] A. Strahan in 'The Country around Merthyr Tydfil,' 1904, p. 77, *Mem. Geol. Surv.*

In the Tawe Valley the Ynysarwed Vein is exposed to view in the landslip-hollow of Daren Wyddon, and is easily traced thence by means of the great rock above it to Cwm Clic. Near Pen-y-graig an open level shows 2 feet 8 inches of coal with a sandstone roof. In Cwm Clic a level was driven about 200 yards in this seam, proving it to be 3 feet 6 inches thick, but much broken and a bastard anthracite. A coal 1 foot 6 inches thick has been tried in a level 130 yards further south, and may represent the No. 1 Rhondda Seam. A section plotted through Mynydd March-Hywel from the crop of the Gelliau Vein to that of the Ynysarwed Vein in Cwm Clic indicates that there must be not less than 420 yards of measures between the two veins.*

Mynydd Allt-y-grûg, on the other side of the Tawe, supports a small outlier of the Ynysarwed Vein. Near the northern end may be seen sandstones resting on the coal, and containing the usual band of conglomerate, with pebbles of ironstone, shales and vein-quartz, 3 feet above the coal.†

A. S.

From the Rhydding or Cwm Llynfell Fault to the Nant Garenig or Gardener's Fault.

The coal which has been taken to represent the Ynysarwed or Rhondda No. 2 Vein, or base of the Pennant Series, appears on the western side of the Cwm Llynfell or Bryn-llefrith Fault at Pen-rhiw-fawr, south of Cwm Llynfell. It lies at the foot of a conspicuous crag of coarse Pennant grit containing ironstone-nodules, quartz-pebbles, and fragments of carbonised plants—characters which farther east are often observable in the roof of the Ynysarwed and Rhondda No. 2 Veins.

The vein has been worked by slopes on Penlle 'r-fedwen and is still occasionally got by the farmers ; it is about 2 feet 6 inches to 3 feet thick. In one of the slopes the following section was obtained :—

	Ft.	In.
Sandstone with ironstone-pebbles	–	–
Sandstone	1	0
Sandy shale	3	6
Coal	3	3

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* See also another estimate in 'The Country around Swansea,' 1907, p. 65, *Mem. Geol. Surv.*

† A. Strahan in 'The Country around Merthyr Tydfil,' 1904, pp. 76, 77. *Mem. Geol. Surv.*

The coal formerly worked south of Pen-how is probably the same vein. though the sandstone-roof seems to be replaced by one made of shales. A little farther west the vein appears to be cut by an easterly downthrow—possibly a continuation of the Dyffryn Fault—west of which it can be traced by old crop-works and a low sandstone-feature; the coal is said to be 1 foot 5 inches thick. The overlying sandstone has been quarried on the south side of Nant Hopkin, here again containing ironstone-nodules, carbonised plant-remains, and pebbles of coal.

Some difficulty has been met with in attempting to determine which vein on the west of the drift-filled valley of Cwm-y-gors should be taken to represent the Ynysarwed Vein on the east. Two veins have been worked round the edge of the plateau north-west of Nant-melyn; the lower is described on page 110; the upper has been taken to be the Ynysarwed Vein. There are several small levels on the coal in Nant-melyn, and the overlying sandstone has been quarried. Farther to the north-west, at the carnau shown on the map, the old levels are more numerous, and from this point the crop presumably runs south-westwards into the Nant Garenig Fault.

The Ynysarwed Vein is succeeded by thick alternating beds of shale and Pennant sandstone; on Penlle'r-fedwen it is followed at a little distance by a band some 12 feet thick of coarse grey quarzitic sandstone of the type usually known as 'cockshot.' Next follow shales in which one or two coals have been worked; one of these can be readily traced by old slopes round the north of Bryn-melyn; it has a hard shale or shaly sandstone roof. One of the levels on the extreme northern part of the crop yielded the following measurements:—

	Ft.	In.
Sandstone, flaggy	–	–
Coal	3	0
Clay		6
Coal, seen to	1	0

The coal is still occasionally wrought by the farmers. Another section in a level one-third of a mile north of Fforch-egel showed:—

	Ft.	In.
Shale, hard	8	0
Sandstone	1	6
Coal	2	0
Clay		6
Coal, seen to	1	0

This vein is possibly the same as that formerly worked along the south-east side of the Nant-y-gaseg valley, where it has a soft Pennant roof.

Still higher beds in which sandstones are more frequent make up the terraced northern end of Mynydd Gwrhyd. A coal runs along the side of the mountain west of Bieting and in a level west of Gelli-warog showed 18 inches of coal and the top of another seam a few feet below.

West of Gwrhyd-uchaf Farm a quartzitic band (cockshot) is exposed. Still higher a coal 1 foot 6 inches or so thick has been worked along the foot of a Pennant crag 15 or 20 feet high, north of Crach-llwyn.

West of Cwm-y-gors a vein associated with shales can be traced by a long series of old crop-works around Bryn-mawr at the northern end of Mynydd Carn-llecharth from Pwllau-Watkin on the east to Tresgyrch-fawr on the west, where it is cut off by the Nant Garenig Fault. The coal is occasionally worked at Lletty'r-crydd and is 2 feet or more thick. At Nant-y-gafaelau a line of crop-works some few yards below the coal may have been on a band of mine.

T. C. C.

The valleys of Cwm-du, Cwm Egel, and Cwm-y-gors lie in the great barren belt of measures which separates the Hughes and the Ynysarwed Veins. Except for an occasional coal-smut and a few quartz-grits, such as occurred at the same horizon on Mynydd March-Hywel, nothing is to be seen but alternations of Pennant sandstones with subordinate shales. Some old levels at Cefn-lan are said to have been worked for mine.

The Rhydding or Cwm Llynfell Fault crosses the Tawe a few yards below Cwm Clic. It passes under Plâs-cil-y-bebyll in a due northerly direction, having a strong bank of Pennant on its easterly or upthrow side, and the Wernffraith Vein on its western side. In crossing the valley the fault turns to the north-west, and is visible a few yards south of the culvert by which Nant-Clic passes the railway. The outcrop of the supposed No. 1 Rhondda Seam mentioned on p. 142 occurs at about 420 feet above Ordnance Datum on the upthrow side, and close by the Graigola Vein crops out at 380 feet above that datum on the downthrow side. Here, therefore, we can get a direct measurement of the throw. From the Graigola to the Hughes Vein has been proved in Waun-y-coed Colliery to be 232 yards (Vertical Sections, Sheet 87); from the Hughes to the Ynysarwed has been estimated already to be 420 yards. The supposed No. 1 Rhondda is about 70 yards above the Ynysarwed, and therefore 582 yards below the Graigola. To this must be added the difference of level of 40 feet between the two crops, giving a total of 595 yards as the throw of the fault. The throw increases southwards to a maximum of about 760 yards near Bryn-côch.*

The Dyffryn Fault, which runs parallel to the Rhydding Fault is a downthrow east, and forms with it the well-known trough of Dyffryn. Its position in the sides of the Tawe valley can be determined pretty closely on surface-evidence. An easterly dip of 75° at the southern end of a peat-bog near Cwm-gellillwyd is evidently due to the close proximity of the fault. At Craig-gelli-nedd again easterly dips of 40° to 60° prevail, while close by on the other side of the fault there is a continuous outcrop of the Hughes Vein with a dip of 25° to 35° to the south-east. On the other side of the Tawe the dingle of Cwm Shon traverses rocks dipping at 10° to 15° south-south-east, while close by to the west, under Craig Llangiwg, an east-north-easterly dip of 45° prevails. This same arrangement continues for a mile northwards, and indicates that the fault must be lessening in that direction. As a fact, the evidence for a fracture becomes gradually less convincing, and it is doubtful whether the fault has much importance further north than Llwyn-y-pryfell.

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* 'The Country around Swansea,' 1907, p. 66, *Mem. Geol. Survey.*

In the Tawe Valley it throws the Graigola on the east below the Hughes Vein on the west, a shift of less than 300 yards, but it is accompanied both here and at Llangiwg by strong flexure, which makes it difficult to estimate the shift effected by the fracture alone. Like the Rhydding Fault it increases southwards, the throw at Wernddu (Sheet 247), where the Graigola on its west side is at a higher level than the Bryn-côch Vein on its east side, being about 440 yards. Beyond this point it diminishes southwards. The measures introduced by these great trough-faults include some of those which lie above the Wernffraith, or Primrose Vein, and which we class as the Upper Coal Series (p. 71).

It will be seen that the Rhydding and Dyffryn Faults attain their maxima in the same region, namely near Bryn-côch. The necessary result of so large a subsidence in a limited length of trough is apparent in the synclinal form of the strata. Thus the Wernffraith and Graigola Veins which crop out at Cil-y-bebyll attain a depth of 178 and 434 yards respectively near Bryn-côch,* but come to the surface again near Neath Abbey. No comparable synclinal arrangement exists in Mynydd March-Hywel on the one side, nor in Alltwen and Mynydd Drumau on the other side of the trough.

The tract concealed by the alluvium of the Tawe is unproved, but there are reasons for suspecting that a disturbance may lie beneath it, as is the case in the Vale of Neath. Not only do the straight trench-like character and direction of the valley recall the features of the Vale of Neath, but both the Rhydding and Dyffryn Faults in crossing it suffer a remarkable deflection from their course as described (*see also* p. 176), a deflection which cannot be explained as the effect of a depression in the surface on the outcrop of a low-hade fracture. The crops of some of the veins, moreover, do not match on the two sides of the valley, for the Hughes Vein, or what is believed to represent it, on the north-west side, crops out at the level of the river nearly in the direction of level-course from the Waun-y-coed Shaft* on the south-east side, where it lies at a depth of 214 yards. There appears, therefore, to be here a considerable downthrow to the south-east; but, on the other hand, the position of the Red

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* *Vertical Sections* (*Geol. Survey*), Sheet 87 (1904).

Vein as proved in the Crimea and Ynys-y-geinon Pits (p. 97) suggests no displacement further up the valley.

The so-called Hughes Vein proved in the Waun-y-coed Shaft was also being opened in a slant at the foot of the hill in 1899. In the shaft it consisted of coal 8 feet, stone 3 feet, and a lower coal 3 feet thick. If not the Hughes Vein it is almost certainly one of the Hughes group. On the north-west side of the valley it crops at the foot of a sandstone-crag and above a considerable landslip. It was worked at the old Cwm-nant-du Collieries and again near Cwm-nant-Lleucu, and the probability of its being the Hughes is strengthened by the fact that there is here no seam of any consequence below it. Except for a smut in Cwm-du (above Ynysmeudwy), there is known nothing nearer than the Ynysarwed.

We pass now to the west of the Dyffryn Fault. The crop of the Hughes is conspicuous on Allt-wen. In one of many old openings upon it may be seen two coals, each 1 foot 4 inches thick, with 1 foot of stone between. Much of the ground was drained and worked by a level opening on the bank of the Tawe 280 yards below Pontardawe Bridge.

Here again we get evidence suggestive of a disturbance below the alluvial tract of the Tawe. The Hughes Vein of the south-eastern side crops out in the railway 350 yards south of Pontardawe Station and reaches the level of the river close by. On the north-western side it reappears at Craig-tre-branos and reaches that level much further to the south. Here also a downthrow to the south-east is indicated.

The hamlet of Craig-tre-branos is situated on a landslip consisting chiefly of the softer measures associated with the Hughes Vein and bounded on the west by a crag of the rock above the vein. Two coals have been worked, but they are said to be sulphury, and, though fit for local farm-purposes, to be of no use for artificial fuel, for which they were sought. At Gelli-onen the upper of the two consisted of coal 15 to 18 inches, stone 13 to 17 inches, and bottom coal 18 to 24 inches. A level near Ty'n-y-pant was being worked for local household coal in 1900 and showed coal 2 feet, stone 10 inches, and bottom coal 2 feet 2 inches. It should be remembered that the Hughes Vein is the lowest of a group near Neath and Swansea (Vertical Sections, Sheet 87) and that though the Craig-tre-branos seams correspond in position to the group, there must always be a doubt which members of it they represent.

These two veins have been worked along the eastern and northern slopes of Mynydd Gellionen to Llecharth-fawr, but north of that farm one vein only has been recognised. A level in it close to its intersection with the Gardener's Fault shows 31 inches of coal with a shale-roof.

The Graigola Vein crops under Craig Cil-hendre and Craig-Ola from which it takes its name, the crag in both cases being due to the massive rock overlying the coal. The seam ranges from 5 to nearly 6 feet in thickness, and has been got both by slants in the crop and by a level driven through the Dyffryn Fault south of Wern-ddu. At Craig-Ola it contains a parting of 3 to 13 inches in thickness. About 30 or 40 yards below it an inferior vein has been tried which was called the Maesmelyn, in accordance with the sequence proved in the Main Colliery (Vertical Sections, Sheet 87, No. 4).

The rocks between the Graigola and Wernffraith Seams have been traversed in the shafts of the Cwm-nant-llwyd and Waun-y-coed Collieries (Vertical Sections, Sheet 87, Nos. 1 and 2). In the former the distance between the two seams was ascertained to be 196 yards, and to be occupied almost wholly by sandstone. These same veins at the Main Colliery (Sheet 247, Vertical Sections, Sheet 87, No. 3) were 252 yards apart, the increase being due to the development southwards of some shaly strata intervening between the Greenway and Tyr Edmond Seams. From the Graigola to the so-called Hughes Vein of Waun-y-coed is 232 yards. The total distance therefore from the Wernffraith to the Hughes group is likely to be about 430 yards at Cil-y-bebyll, while judged by the section of the Main Colliery, No. 1 Pit and the Skewen Pit (Vertical Sections, Sheet 87, No. 3 and 4), it is at least 100 yards more 3 or 4 miles further south.

A. S.

From the Nant Garenig or Gardener's Fault to the Loughor Valley.

The Nant Garenig Fault produces a large downthrow west in the lower coals (p. 112), and in the Red Vein (p. 111). Its shift of the base of the Pennant Series is still more marked and causes a horizontal displacement of the crop of no less than two miles.

West of the fault the supposed Ynysarwed Vein reappears on the west side of Cwm Garenig on the slopes south of Cwm Garenig Farm, and may be traced up the side of the valley by a feature and by old crop-works to a point some 200 yards south of Penlle'r-eglwys. The coal is said to be about 2 feet thick, and has a soft roof. A lower seam which crops a little farther north and runs up to Penlle'r-eglwys is described on p.112. Here the vein is thrown down westwards again by the Glyn-môch Fault, apparently a branch of the Nant Garenig Fault, but west of it it has been worked on the crop southwards to Waun-hîr, where the coal, with soft sandstone roof, was being got in 1901. Thence it can be traced by occasional old crop-works in a south-westerly direction past the Butcher's Arms near Bwlch-y-mynydd—where it is known as the Butcher's Vein—towards Nant-y-cadno; it was being worked south-east of Llwyn-y-cwm [Llwyn-y-cwn] and is said to be 2 feet 6 inches thick, but sulphury in quality. Beyond this point it is cut off in Nant-y-cadno by the Bettws Fault.

The Bettws Fault, a great downthrow west, has a marked effect on the Carboniferous Limestone and Millstone Grit at Dinas, west of Llandybie, and again farther south at Ammanford in the Red

Vein. It similarly throws the base of the Pennant Series northwards from Nant-y-cadno (the northern branch of Cwm Cathan) to beyond Maes-llêch. The coal which is taken as the representative of the Ynysarwed Vein was worked at the old Garn Swllt Colliery, where the following section, communicated by Mr. John Roberts, is presented :—

Old Garn Swllt Colliery.

	Ft.	In.
Rock top, very strong		—
Rock, flaggy, and in layers of about 1 inch	1	6
Clod, soft, with rashes of coal, 1 inch to		4
Coal, clean, strong (supposed No. 2 Rhondda)	2	11
Fireclay	1	6
Clay, soft, whitish, 1 inch to		2

Pennant Sandstone is worked in a large quarry some 300 yards west of the old levels, and the smut of a coal, probably the vein worked, is to be seen at the entrance to the quarry. From this point the coal can be traced south-westwards by occasional old crop-works to Ynys-llwchwr, where it was formerly worked by levels. In a level at Garnant this seam is said to be 18 inches thick.

Above the Ynysarwed Vein the alternating Pennant sandstones and shales with occasional bands of quartzitic rock (cockshot) form the higher slopes of Mynydd Bettws, and again west of the Bettws Fault on the east side of the Loughor Valley. A coal probably not more than 9 inches thick lies some little distance above the Butcher's Vein and has been worked at Fullmoon and south of the Butcher's Arms. Still farther south at Blaen-y-cwm at the head of Cwm Cathan a thin vein crops out at the top of a flagstone-quarry and is reported to be the Fullmoon vein, but this is doubtful.

Still higher in the series a group of thin and valueless veins crops out beneath Penlle'r-castell at the northern extremity of Mynydd-y-gwair; they have been worked on the slope north of the camp, but probably none reaches 1 foot in thickness. A vein at about the same horizon crops out at the top of an old landslip three-quarters of a mile farther south-west. It is not unlikely that these represent the Hughes group of veins of the region farther south (pp. 150, 153).

T. C. C.

The Gardener's Fault, which is the southward continuation of the Nant Garenig Fault, is a downthrow west of nearly 300 yards in Sheet 247, and, though its exact throw is unknown, it is certainly large in the district under description. It passes a few yards west of Gelli-onen-isaf and runs thence down a swampy hollow to Allt-y-fanog. It had not been reached in 1900 from Cathelyd, but will doubtless be found to form the eastern limit of those workings in the Graigola Vein. It appears to cross Nant Llecharth

400 yards below Llecharth-fawr, and then to traverse some swampy ground with an occasional exposure of highly inclined sandstone to the north-west of Llecharth-fâch. To the south-east of that place there are old levels in a coal which is said to be highly bituminous and which it was suggested, without sufficient reason, might be the Wernffraith or Four-feet Seam. At this point the Hughes Vein on the eastern side and the Graigola Vein on the western side crop at about the same distance from the fault, and both dip towards it, and so that their relative levels at the fault, when known, will give the throw. It is probably over 250 yards.

Further north the position of the fault is less clearly defined. The syncline, however, continues, for a west-south-westerly dip prevails all over Carn Llecharth, whereas in the adjoining part of the Clydach brook the dip is uniformly east, wherever the rocks are open to view.

In Cwm Clydach commences a syncline which forms an important structural feature of the coalfield under Rhyd-y-pandy and Bryn Whilach in Sheet 247. The syncline runs about 5 miles and trends west-south-west, or nearly at right angles to the syncline which accompanies the Gardener's Fault. Its position is obvious in the Clydach, for the Graigola Vein cropping out under the bold Graig-felen slants down northwards to the river-bed at Cathelyd, but re-emerges 1,000 yards further up the valley, and then rises steadily to its north crop on Mynydd-y-gwair. Westwards the syncline passes under the peat-bog of Rhydd-waun to Rhyd-y-pandy in the adjoining map (Sheet 247).

The Graigola Vein under Mynydd Gelli-Wastad consists of coal 1 foot 3 inches, rashings 1 foot, bottom coal 2 feet 9 inches, but higher up the Clydach Valley the rashings thin out to a mere parting. At Cathelyd (Moody's Graigola) Colliery, the vein is worked by a level driven at Craig-yr-Allt and yields the following measurements :—

Graigola Vein, Cathelyd.

	Ft.	In.
Cliff - - - - - - -	—	
Coal - - - - - - -	1	1
Dirt - - - - - - -	0	2
Coal - - - - - - -	4	6
Soft coal and dirt - - - -	0	5½
Fireclay - - - - - -	1	3

It gives much small coal, which is used for the manufacture of artificial fuel.

On the opposite side of the valley lies the Western Merthyr Colliery, in which access is gained to the vein by a slant starting about 30 yards above it. Rising northwards the vein crops close by, but the hill-side is cumbered with one of the largest landslips in South Wales, and it is not till we reach Cwm Clydach factory that we see rock-in-place below the vein. One hundred yards below the factory a coal 18 inches thick is visible in the bed of the river; 400 yards above it there is an old trial-shaft and a crop of coal with much shale, while on the hillside south-west of Ty'r-waun a trial-level has been started in a seam lying about 70 yards below the Graigola and yielding the following section according to Mr. S. L. Gregor :—

Ty'r-waun.

	Ft.	In.
Top coal	0	10
Coal and stone	2	6
Stone	1	6
Coal	2	0

Lastly a trial-pit at Melin-y-Cwm was sunk 43 yards to a vein, of which the following section was supplied by Mr. Jonah Jones :—

Melin-y-Cwm Trial Pit.

	Ft.	In.
Top coal	0	9
Inferior coal and stone	2	3
Coal	0	10
Pinchin	0	1
Bottom coal	0	9

All these little seams have been suggested at one time or another as representatives of the Hughes Vein. None of them are sufficiently far below the Graigola Vein, and the position of the Hughes Vein remains yet to be proved. The fact that no crop has yet been found for it, except possibly some worthless smuts on Penlle'r-castell and in Cwm Cathan, makes its existence as a workable seam doubtful.

At the Daren Colliery a wash-out was encountered in the Graigola Vein to the south of the Drift. The workings from the south reached what was thought to be the other side of the same wash-out. A tract of about 700 yards width on the south-west side of Banc Maes-tir-mawr thus remains unworked and unworkable. In several of the old levels along the north crop of the Graigola Vein the coal is still visible. It seems to have been about 5 feet thick and in places there was a parting of half an inch thickness 6 inches from the base.

From the Bettws Fault to the Loughor Valley the Graigola Vein is free from faults of any importance, and its crop runs down the Dulais Valley and round Cefn Drum with great regularity. In the valley it is being worked by the Birch Rock Colliery and is found to dip 2° or 3° east of south at 5 to 6 inches to the yard.

A small seam has been dug into at the northern end of Cefn Drum, about 20 or 30 yards below the Graigola Vein, and a clay associated with a coal-smut crops 600 yards further north again. These may represent the Three-feet and Two-feet Veins of Swansea. They appear to be of no value. An old level, 200 yards north of Tir-bâch in the Camffrwd Valley, shows a coal 1 foot 3 inches thick about 3 yards above the Graigola Vein.

In the Western Merthyr Colliery,* access to the Graigola Vein is gained by a slant, the vein being about 30 yards below the surface. The main slant runs along the north side of the Rhyd-y-pandy syncline in measures dipping south-south-east at 3 inches to the yard. Several north-westerly faults were passed, all with downthrows to the west. The first, 200 yards from the mouth, has a throw of 36 yards; another of 36 yards throw passes under Rhydd-waun; a third of 34 yards throw, but dying out northwards, runs under Rhyd-y-pandy; the fourth with a throw of 19 yards passes under Rhos-fawr; and, lastly, a fifth not yet reached in the workings is to be expected about 23 chains west of the Rhos-fawr Fault. The last-mentioned appears to have led to the failure of the Felindre Colliery. The shaft was sunk to a depth of 173 yards to what was believed to be the Graigola Vein, but faults were met both to the east and west of the shaft and no coal was raised.†

As a result of the combined effects of faults and syncline, the Graigola Vein lies at a depth below Ordnance Datum of 86 feet near Rhos-fawr, between the Rhos-fawr and Rhyd-y-pandy faults, and at a depth below that datum of 360 feet near Rhyd-y-pandy between the same two faults. The surface of the rock, as exposed under Glacial Drift at Rhyd-y-pandy is 367 feet above that datum, which leaves room for 727 feet of measures above the Graigola Vein. Turning to Vert. Sects., Sheet 87, we find that the Five-feet Vein might be expected to occur about 350 feet above the Graigola (or Six-feet) Vein, and the Four-feet about 700 or 800 feet above that vein. That is to say, there would be ground for the Five-feet Vein at Rhyd-y-pandy, whereas the Four-feet would be just 'out.' The Rhos-fawr fault, however, might be expected to throw the Four-feet in, and the Felindre fault, which is still an unknown factor, to throw it still deeper. For this reason a hypothetical line to indicate the horizon of Four-feet Vein has been drawn upon the map upon both sides of the syncline to the west of the Rhos-fawr Fault. The existence of the vein as a workable seam is yet to be proved. The nearest known workings upon it are at Bryn Whilach a mile to the south-west, and at Ynys-forgan to the south (both in Sheet 247). The north crop is wholly obscure, the vein apparently having dwindled away before reaching the surface. The same remarks apply to the Five-feet Vein; it is not known north of Cefn-gyfelach and Penrhiw-felen as a workable seam.

These calculations are founded on the view that the Graigola Vein of Western Merthyr is the same as the Six-feet Vein of Swansea. That view, however, is not universally accepted,‡ and one argument used against it has been derived from some levellings made in the Western Merthyr Slant. Under Cefn-betingau * the Graigola will be about 560 feet below Ordnance Datum. At Bryn Whilach Pit the Four-feet Vein is 6 feet below that datum and rather lower in the syncline. The Graigola Vein, if it is the Six-feet, should therefore be about 760 feet or more below that datum at Bryn Whilach, that is to say, 200 feet lower than at Cefn-betingau. The only fault as yet proved, namely one on the eastern side of Penrhiw-felen Pit, is a downthrow to the north-east, and adds to the difficulty of accounting for the increased depth. An explanation is sought in the theory that the Graigola Vein of Western Merthyr is the Five-feet of Swansea, which lies more than 100 yards above the Six-feet.

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* Information from Mr. S. L. Gregor.

† Information from Mr. John Roberts.

‡ For a discussion of this subject, reference should be made to 'The Country around Swansea,' 1907, pp. 80, 81, *Mem. Geol. Survey.*

It is true in the first place that the Penrhiw-felen Fault ranges between the two localities mentioned, but, so far as is known, it dies out before reaching the syncline, for it would pass through ground worked at Bryn Whilach, where only small downthrows to the west were found. In the second place another fault not yet found is likely to form a large downthrow west. The two touched at Felindre Colliery unite southwards to form one which runs at the foot of the bank of sandstone 150 yards west of Salem Chapel, in a belt of ground occupied by white clay. Thence it may be assumed to continue into the westerly downthrow which throws in the Four-feet Vein at Cwm-rhyd-y-cwrw. Northwards from Felindre Colliery the one branch has been found in the Graigola Vein in Cwm Gelltfechan, and is visible in the river-bed close to Daren Colliery, while half-a-mile further north its shift of the crop of the vein is obvious. The other branch ranges further west and is likely to be the fault which throws the Graigola down about 40 or 50 yards westwards on the south side of the Dulais Valley. At Blaen-ffynnonau it has a similar effect upon the thin coals mentioned on p. 148, which we believe to represent the Hughes group. Further north again it becomes the Bettws Fault and probably continues past Llandybie to the limestone as the Dinas Fault.

It seems likely, therefore, that this line of faulting, possibly with others not yet suspected, may serve to account for the estimated increase of depth to the Graigola Vein under Bryn Whilach. To correlate the Graigola with the Five-feet Seam would introduce many difficulties.

On the assumption that the Graigola was the Six-feet Vein search was made for some representative of the Five-feet Vein, and though no coal was seen, clays and other measures underlying a massive rock were found at about the right horizon. These measures form a terrace in the hillside from Craig-cefn-parc northwards and have been dug for clay on Mynydd-y-Gwair. The same feature is well marked south and east of Daren Colliery in the Lliw Valley.

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* This and the remainder of the localities mentioned are in Sheet 247.

A coal cropping out above Cwm Dulais hamlet, and about 1 foot 5 inches thick, but impersistent, may represent the Five-feet Vein. It lies about 65 yards above the Graigola. What may be the same vein is shown to a thickness of 2 feet 1 inch close to Golden Grove, but the ground is disturbed by the proximity of the Gorseinon Fault (p. 164). The crop of the Four-feet Vein along the Lliw Valley is wholly conjectural. No evidence has been obtained of the existence of that seam in a workable form along this part of its north crop. For a continuation of the account of these veins westwards the reader is referred to p. 164.

To the west of the Loughor Valley we come to a series of large faults, about which much yet remains to be proved. But as far as regards the eastern side of the valley there exist no such complications, for the uninterrupted crop of the Graigola Vein along the north-western side of Cefn Drum makes it certain that there is no fault of importance through this hill, so far west at least as Gwaen-Camffrwd, and makes it improbable that there is one through Graig-fawr. The same conclusion also may be drawn from the crops of some small seams in the western slopes of that hill. Among them we might expect to recognise the Hughes group, if it exists.

In descending the slope towards the southern end of Graig-fawr we cross a line of old levels on a coal about 15 inches thick. The seam crops under Troed-y-rhiw, and slants thence up the hill to Llan-dremor-uchaf but there is no evidence of the existence of any coal for more than 700 yards. Lower down a coal has been opened out which crops under Rhosilly, and gives the following section:—

	Ft.	In.
Clift - - - - - - -	—	
Top coal - - - - - -	1	3
Fireclay - - - - - -	3	0
Coal - - - - - - -	1	6
Clod - - - - - - -	0	6
Bottom coal - - - - -	0	10

This vein also slants up the hill northwards and may be estimated to pass near Tan-y-graig at the head of the Garnant dingle. A few yards further on there are some trial-holes in what is either the same seam or another close to it, by the roadside south of Bryn-y-cyffon. On the east side of the Bettws Fault the same horizon is indicated by a bed of shales with a massive sandstone over it at Blaen-ffynnonau, and the feature formed by these strata when followed round Pen-twyn-mawr leads to some coal-smuts in Cwm Cathan, which we have already referred to as being the most probable equivalents of the Hughes group we have been able to find. It is interesting therefore to find that the Rhosilly vein was thought by Mr. J. Roberts to be a member of the Hughes group, and to resemble the Bodwr Vein.

At the foot of the hill and 180 yards north of Ty'n-y-cerig a trial-level has been opened showing:—

	Ft.	In.
Sandstone	—	
Shale about	8	0
Coal and shale	0	4
Shale	2	0
Coal and shale	0	3
Shale	3	0
Coal	1	0
Shale	—	

A section plotted from Hendre-wen through Graig-fawr and Mynydd Pyscodlyn to the Lliw near Lletty Thomas gives the following approximate thickness:—from the estimated horizon of the Four-feet Vein to the Graigola, or Six-feet Vein, 250 yards; from the Graigola to the little seam of Troed-y-rhiw, 100 yards; from the Graigola Vein to the Rhosilly vein (or supposed Bodwr), 230 yards; from the supposed Bodwr to the Ty'n-y-cerig vein, 200 yards. Again, measuring down from the supposed Hughes Vein on Pen-y-cwar to the Garn Swllt Vein we find a thickness of about 400 yards between the two, on the supposition that the dip averages 10°, or of 310 yards on the supposition that the dip averages 6°, which perhaps is more probable.

A. S.

West of the Loughor Valley.

(1) *Northern part of the Pennant Tract.*

The determination of the base of the Pennant Series to the west of the Loughor is based upon a general comparison of the measures east of the river with those to the west. On Mynydd Bettws, on the one side, as has been seen (p. 117), a well-marked band of cockshot rock occurs about 900 feet below a coal which we regard as the Ynysarwed Vein. This coal is the lower of two veins separated in places by about 230 feet of sandstone and shale, but followed by a thick mass of sandstone. On the other side of the Loughor we find a rock similar to the cockshot, and above it, at a distance of 900 to 1,200 feet, two coals separated by sandstone and shale, but followed by thick sandstones. The two sides, therefore, correspond fairly well.

Proceeding on the assumption that the lower of these seams is correlative with the Ynysarwed Vein, we should expect from the position of the cockshot outcrop that the base of the Pennant would lie under the valley-gravel near Erw-wastad, and this as a fact is about in the line of level course from Garnant (p. 148).

On the western side of the Hendre Fault the lower of two coals which crop out near Erw-wastad occurs at such a position with respect to the cockshot rock of Greynor as points to its being the base of the Pennant Series.

This seam may be traced by crop-workings from the dingle above Erw-wastad mentioned on p. 132, where it is thrown by the Hendre Fault against shales of the Lower Coal Series, to the low ground north-west of Pentre-hardd, where it is crossed by the Glyn-Wallis

Fault. Between these places it has been recently worked at Gelli-Organ where it is said to be sulphurous and about 3 feet thick, and at Glan-cwm-bychan a quarter of a mile farther to the south-west, where it is seen in a cross-measure drift to be 2 feet thick.

Of the measures, about 200 feet thick in all, between this and the upper coal the lower third consists chiefly of sandstones, well exposed in the dingle at Glan-cwm-bychan. The rest is shale with some quartzitic sandstones and ironstones. These beds and the upper coal, known as the Llech-y-gareg Vein after a farm now demolished, together with the overlying sandstones are exposed in the same dingle. Here the vein, said to be from 2 to 2½ feet thick, and also another, said to be 18 inches thick, in the shales below, have been worked. To the south-west the coal may be traced by means of workings, some comparatively recent, to the Glyn-Wallis Fault at Pentre-hardd.

In the dingle at Llech-y-gareg the upper seam occurs in shale about 12 feet below coarse sandstone with coal partings. This rock forms the base of a thick series of Pennant Sandstones of finer grain which have been quarried at Erw-wastad and Pentre-hardd. A thin band of shale in these rocks has been the chief cause of a great landslip at Cwm Daren, south of Sychnant. For the dip being downhill and as much as 15°, the sandstone above the shale where undercut by the Loughor has broken away from the escarpment in masses up to 200 yards long, probably along the north-north-west joints which are dominant in the neighbourhood, and has slipped downhill in a confusion of blocks of all sizes. That this landslip was of post-glacial age is to be inferred from the absence of glacial débris in the ravines between the slipped masses and from the fact that a strip of glacial gravel along the river appears to have been involved in the slip. The sandstone above the shale as exposed in the ravines is frequently coarse and on one horizon full of large plant-remains and pebbles of clay-ironstone.

West of the Glyn-Wallis Fault some coals of which the lowest has been worked near its outcrop are exposed in the dingle south of Plâs-newydd. As the sequence of strata there has a general resemblance to that at Erw-wastad and as the lowest visible coal of the group has a position in the series not more than 1,300 feet above the cockshot rock in the Gwili (p. 133), it has been selected as the representative of the Ynysarwed Vein. Consequently the Glyn-Wallis Fault has here a downthrow west of about 200 yards. Above the coals a thick mass of Pennant sandstones extends south to Gwal-yr-hwch where in quarries it is seen to be more siliceous and like a quartzite than usual. This is shown by both its compact appearance and the occurrence in it of druses of quartz and pyrites, but in a microscopic section (E. 3592) of even the most siliceous variety, which was obtained from a quarry 200 yards south-east of the farm, it is difficult to distinguish any secondary silica. The clastic grains seem to fit so closely together on account of their irregular shapes as to leave little space for cementing material.

The hill between Gwal-yr-hwch and Glyn-Wallis shows a synclinal structure, and some shale seen near Glyn-Wallis may be the same as a band interbedded with the quartzitic sandstone south of Gwal-yr-hwch. Also, south of Pentre-hardd the throw of the Glyn-Wallis Fault which, north of that place, has a westerly downthrow of 200 yards, rapidly lessens in consequence of this syncline, which causes a descending sequence on the west to be thrown against an ascending one on the east. About 350 yards south of Pentre-hardd the westerly downthrow vanishes, and at Glyn-Wallis, where the fault disappears beneath gravel, it is easterly and estimated to be 150 yards in amount.

From Glyn-Wallis south-westwards there appears to be an unbroken ascending sequence of sandstones with subordinate shales and occasional thin coals. Llanedy Church stands in a strike-hollow marking an outcrop of shale, and St. Edy's Cave is a slight recess in a line of crags of the overlying sandstone. Higher up in the series two more bands of shale underlie coals, one of which, with a reputed thickness of 2 feet, has been worked at the outcrop at Pant-y-dwr-uchaf and to the south-east, while the other has been worked a little about 300 yards to the south-west.

With these exceptions sandstones extend as far as a bold scarp at Fforest Plantation, which is due to their interruption by a considerable mass of shales followed by more sandstones capping the feature. The shales are not less than 200 feet in thickness, and contain several coals, of which one, near the middle, has been worked along the outcrop where the scarp plunges into the Loughor Valley on the one side and into the Gwili on the other. It is said to be a steam-coal 3 feet thick, but its identity is doubtful. If a seam worked at Fforest is the Six Feet (p. 165), the Plantation group is much too low for the Three and Two Feet Veins, and rather too high for the Hughes group.

Assuming that the shale near Glyn-Wallis is correctly identified with that south of Gwal-yr-hwch the thickness of measures between the base of the Pennant, near Plâs-newydd, and the chief Plantation vein appears, on a section being plotted, to be between 2,200 and 2,500 feet, the lower figure being probably nearer the truth. This estimate, however, is of little use for comparison (pp. 161 and 169), on account of our ignorance of the exact horizon of the Plantation vein and of the dip over much of the ground.

The following plants (E. D. Nos. 226, 227) which have been kindly identified by Mr. R. Kidston, F.R.S., were obtained from an old slant on this vein 430 yards S. 10° W. of Heol-y-dwr:—*Linopteris münsteri*, Eich. sp., *Mariopteris muricata*, Schloth. sp., *Neuropteris ovata*, Hoffm.

About 350 feet above the vein is a narrow band of shales with thin coals. (For a description of higher beds to the south see p. 165).

In the Gwili Valley the crop of the Plâs-newydd (or supposed Ynysarwed) vein is thrown far to the north by the Bryn-gwili

Fault (p. 178). West of this, as far as Llannon, the ground is so much disturbed, and obscured by drift, that only a general idea can be obtained of its structure.

According to Mr. Cantrill's observations the supposed Ynysarwed Vein leaves the west side of the Bryn-gwili Fault near Rhyd-sarnau two miles on the Pontardulais Road from Cross Hands. The coal, which lies about 1,000 feet above the cockshot rock of Gelli'r-odyn has been worked by levels in a dingle at Rhos-fâch, and by a shaft a little farther south near Ty-gwyn, beyond which it disappears under drift.

To the south, a vein which has been worked to the west of Pen-twyn emerges from the drift at a point where, on the evidence of dips observable near Gelli-Lywarch, the Ty-gwyn vein might have been expected. It appears to occur in a mass of shale overlain by some sandstone which has been quarried hard by. Above the rock comes more shale containing a coal, said to be 2 feet thick, which has been worked along the outcrop east of the farm. As, therefore, we have hereabouts, at about the right position in the series, two veins associated with a mass of shales, in accordance with what was stated on p. 154, we have selected the lower vein as the representative of the Ynysarwed (No. 2 Rhondda) Vein.

The shales are succeeded by sandstones with occasional thin shales and coals which, accordingly, we regard as belonging to the Pennant Series. They dip eastwards, or south-eastwards, and extend eastwards as far as the Bryn-gwili Fault. They are well exposed west of Plâs-newydd Mill in a dingle where the fault, though not itself visible, causes a sharp westerly dip, and throws them against the top of the cockshot rock mentioned on p. 133. Of the coals what is probably one and the same vein has been slightly worked to the west of Ystlys-y-coed-uchaf and north-west of Treneddyn: no others are known.

Further west, beyond a small westerly downthrow ranging north-west towards Dyrclawdd and evidenced by the displacement of a sandstone, a vein which appears to be the same as the lower vein at Pen-twyn has been worked slightly, about half a mile to the west of the farm, up to a fault which throws it against the sandstone quarried at Bryn-withan close by, and referred to on p. 139 as probably of a horizon lower than the Pennant Series. Some distance beyond, however, the Llannon boring (p. 135) started, as we believe, not far below the base of the Pennant. The lower Pen-twyn vein which forms that base is, therefore, shown on the map a short distance to the south, but as the ground is covered with drift nothing is actually known of it hereabouts. It is certain, however, that some sandstone visible at the chapel belongs to the Pennant Series. It is separated from the Bryn-withan sandstone previously mentioned (p. 139) by a fault, and also, possibly, by another from the sandstones forming a hill at Gelli-rhwydd a quarter of a mile south-east of Llannon church. These sandstones also may be confidently referred to the Pennant Series. They are succeeded near the bridge to the south by shales, but beyond this they reappear in consequence of a gentle east-and-west syncline. The corresponding anticline lying to the south of this is also gentle, with the result that no higher horizon than the sandstones is reached before they are cut off by the Pont Morlais Fault, described on p. 162. They are well exposed in the stream that enters the Morlais at the bridge.

To the west, also, the series is cut off by a fault, in this case by the Llannon disturbance which runs in a S. 40° W. direction close by the east side of Llannon, where it is indicated by a line of wet ground and a sharp rise of the surface to the north-west, on which side the Pennant Series appear to be thrown down. Better evidence of a break is obtained by comparing the structures on either side. West of the line, from Llannon to Coed-cyw Mill, the measures either dip to the east or undulate sharply about axes parallel to the fault; whereas, to the east of it, they either dip steadily south-south-eastwards or roll gently about axes at right angles to this direction. South-west of the Morlais the disturbance continues along a swampy valley which commences at Nant-garedig, for at the lower end of the valley the base of the Pennant Series crops out on the south-eastern side not far from a coal on the other side, which is high up in the series (p. 161). This shows that the disturbance here effects a considerable downthrow to the north-west.

The direction of the fault changes hereabouts from south-westerly to west-south-westerly in the lower part of the Nant-garedig valley, where it joins the east-and-west Pont Morlais Fault, suggesting that the two combine to form one. This conclusion is supported by the fact that both faults are lines of compression resulting in northerly downthrows, and by a consideration of the associated folding. For between Llannon and the Gwili there is a gentle anticline parallel to the Llannon disturbance, but southwards, near the Pont Morlais Fault, this fold dies away and is replaced by gentle rolls approximately parallel to the east-and-west disturbance. More definite evidence is yielded by the anticline to which the Cockpithall inlier of Lower Coal Series (p. 139) is due. This fold is traceable from the Morlais to Maes-llydan in a direction parallel to the Llannon Fault. Its origination with the latter is suggested not only by this parallelism, but also by its causing a downthrow to the north-west, on which side it is steeper than on the other, the beds being even inverted through 15°, near Tir-bryn, towards the north-eastern end of the fold. Beyond this, however, close to the Pont Morlais Fault, it suddenly pitches steeply to the north-east, and disappears. Its abrupt termination near the fault and the fact that it pitches steeply in the direction of the downthrow of the fault suggest that fold and fault are different effects of one set of stresses. The fold, therefore, is connected with both the Llannon and Pont Morlais Faults, and we infer that these are branches of the fault in the Nant-garedig valley, and that the structure of the region as a whole may be regarded as the result of one movement.

E. E. L. D.

West of this disturbance the supposed Ynysarwed Vein is known as the Lower Llwydcoed Vein, and, accompanied by a somewhat higher vein, runs round the long plateau of Llwyn-cwta north of Llannon. What is probably the upper coal has recently been opened by a slope half-a-mile south-west of Llwydcoed-fawr Farm, where it is said to be 3 or 4 feet thick with partings, and coal has been got from it at the farm itself. The lower vein does not appear to have been worked, but is exposed in a well 150 yards south-west of the farm.

Northwards the upper vein has been opened on the steep hillside west of Blaenau, and is exposed in a gully at Twll-y-car. It may be traced thence by old levels as far as Gors, where there is evidence of the presence of both the coals. The lower is exposed in a gully close to the house, to a thickness of 2 feet 10 inches; 80 yards farther up the gully (towards the south-east) the position of the upper coal is indicated by débris, a thickness of about 30 feet of shales separating it from the lower. The latter is not known farther, but the upper coal can be traced by old crop-works as far as the road from Tumble to Llannon, beyond which it is presumably cut off by the Tumble Fault.

West of the Tumble Fault, which as has been seen (p. 135) is an easterly downthrow, the supposed Ynysarwed Vein is represented by a vein formerly worked at Pentre, north-west of Llannon, though as there appears to be only one vein it is uncertain which of the two Llwydcoed Veins this represents. Old crop-works show the outcrop along the side of the hill past Pentre Farm, and it can be traced thence into the valley of the Morlais.

Here Mr. Dixon finds that its roof is fine-grained sandstone followed by shale, but the lowest part of the succeeding Pennant sandstone contains small pebbles of quartz and clay and thus resembles the sandstone south of Efail-wen which as will be seen (p. 161) is believed to be on the same horizon. This fact is of interest, as for many miles the Ynysarwed Vein or its equivalents in the eastern part of the coal-field have a conglomeratic roof, but it is of little value for correlation-purposes, as similar conglomerates occur at other horizons. Along the Morlais the measures are thrown by the Dynant Fault against higher members of the same series on the west. West of this fault there are two veins as at Llwydcoed; the lower has been worked along the top of a wooded slope a little north of Pen-llwyn-uchaf where it is 3 feet thick with a 6-inch clod in the middle. From this point it can be traced along the foot of the northern scarp of Mynydd Sylen by almost continuous crop-works to the neighbourhood of Disgwylfa on the western edge of the map. The upper of these two coals has been worked at Pen-llwyn-uchaf and is reputed to be 1 foot 8 inches to 1 foot 10 inches thick; it is unknown, however, a little farther westward.

T. C. C.

South of Disgwylfa the crop of the lower vein is concealed by boulder-clay for some distance, but then rises in the western slope of Mynydd Sylen where it is known as the Brondini Vein after the name of a place to the west (Sheet 229). Thence almost continuous old crop-workings lead to a level, 300 yards north-east of Myrtlehill, where the coal is now being worked (1902).* There it consists of two seams of what is described as bastard anthracite (anthracite approaching steam-coal), each about a foot thick and separated by 6 inches of stone, with a good fire-clay floor and a roof of fine-grained flaggy sandstone. A shaft 80 yards north of the level passed through a seam, 18 inches thick, near the surface, and touched the Brondini Vein at 12 yards' depth. A seam which may be the same as the upper vein at Myrtlehill, but lies at a greater distance above the Brondini Vein, has been worked at Maes-llydan, 700 yards further east. North of Myrtlehill, however, a shaft on Mynydd Sylen, south-east of Cynheidre, sunk 27 yards to the Brondini Vein, passed through merely a 6-inch coal at a depth of 10 yards, and, though the upper vein exists in both the Brondini outlier (Sheet 229) and the Cockpithall inlier (pp. 139, 164), it is unknown in the outlier of Cynheidre.

Above these seams lie the thick sandstones which form the barren moorland of Mynydd Sylen. This area and the neighbourhoods of Cynheidre and Brondini (Sheet 229), lying north-west of the Llannon disturbance, are characterised by a low dip on the whole but are crossed by two rather obscure rolls along axes ranging approximately south-west. The south-eastern fold, which appears to be a monocline, is evidenced chiefly by a sudden steep south-easterly dip along the valley below Pant-yr-yn (a mile west of Llannon) and by what appears to be a similar structure in the outcrop of the Brondini Vein east of Glyn-Sylen, at the other side of the mountain. The axis of the syncline lying to the north-west of this fold passes through the Cynheidre and Brondini outliers in a direction parallel to the adjacent scarp of the Llynfi Rock (Sheet 229). It is evidenced by the low level and low dip of the Brondini Vein in the head of the Lliedi valley and in the outliers at Cynheidre and Brondini, a level lower by over 100 feet than that of the vein on Mynydd Sylen to the south-east. North-west, also, of the axis the beds rise in accordance with a south-easterly dip. These rolls, together with the syncline north-east of Llannon and the Cockpithall anticline previously described, are all linked by position and direction with the Llannon Fault.

At a considerable distance above the Brondini Vein the sandstones of Mynydd Sylen give place to a group of coals and shales, which crops out along the south-eastern slope of the Pant-yr-yn valley. Of the coals two or three have been worked at the outcrop, and the highest, which is about 900 feet above the Brondini Vein, is thrown by the Dynant Fault almost against the Pentre vein (p. 159). This fact enables us to estimate the fault as a westerly downthrow of about 300 yards. South-west of Pant-yr-yn some old workings probably indicate the outcrop of one of the same group and not, as is supposed by some, that of the Brondini Vein.

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* Information about this was kindly supplied by Mr. D. Rees.

Above the highest Pant-yr-yn vein comes another thick mass of sandstones with a general south-easterly dip of 10° to 15°, which holds good nearly as far as Coed-cyw Mill. There along the north-western side of the Llannon disturbance a sharp anticline causes a north-westerly dip of 60°. In the east bank of the Morlais it brings up coal and shale in succession from beneath sandstone, but although the coal has been worked at the outcrop eastwards as far as the Dynant Fault it has not been recognised where it should crop out again to the north. It is probably much higher in the series than those of Pant-yr-yn, which are the first that are known to appear in that direction.

To get a clue as to the horizon of the beds west of the Gwili Fault (p. 178) and south of the Pont Morlais Fault we have drawn a section from the Golden Vein west of Troserch, the nearest identifiable crop, north-north-westwards across unfaulted ground to the crop of the Brondini Vein at Cockpithall (p. 163), and have thereby estimated the vertical distance between those seams to be about 2,300 feet. A parallel section from the Golden Vein, south of Goitre, to a coal-crop at Efail-wen, near Bryn-maen, yields almost the same measurement, namely, 2,100 feet (see also pp. 156, 169).

This Efail-wen vein is thin and poorly exposed. It occurs about 40 feet below the top of a band of shales of considerable, but unknown thickness, underlying another coal which is itself followed by a thick mass of barren sandstones. Taking into account these resemblances to the Brondini Vein and its general position in the series, we infer that the lower vein is the same as the Brondini Vein, and thus fix another point on the base of the Pennant Series.

Nothing further is seen of this vein before it is cut off by faults on both sides of Efail-wen, but near Tre-neddyn it may reappear as a smut 6 inches thick, with a sandstone-roof, which has been tried in the west bank of the Gwili, 550 yards south-south-east of the farm. The vein above it has been worked somewhat on both sides of the road at Efail-wen, but not at Tre-neddyn, where, however, there is evidence of it in another smut a short distance above the first and underlying a thick mass of sandstone. Thus the sequence of rocks at Tre-neddyn resembles in a general way that at Efail-wen, and in the absence of positive evidence of an intervening north-north-west fault we conclude that the lower smut at Tre-neddyn, like the Efail-wen coal, is the local base of the Pennant Series.

On the opposite side of the Gwili, a coal at a much higher horizon outcrops at Fforest Plantation (p. 156). This points to a considerable easterly downthrow in the valley, due to the continuation northwards of the Gwili Fault described on p. 178. Nevertheless, at Tre-neddyn itself and northwards there is no further evidence of this break, but on the contrary, the only fault in the same north-north-west direction is the Bryn-gwili Fault. That fault, however, lies half a mile out of line to the east, has a downthrow west, and cannot be traced south of Gwal-yr-hwch, whereas it runs northwards for a considerable distance.

Crossing the course of these faults where both appear to die away is the Pont Morlais Fault mentioned on p. 158. Evidence for the existence of the fault commences at Gwal-yr-hwch. Immediately east of the apparent terminations of the north-north-west faults there is a wet east-and-west hollow. Some shales crop out along the northern margin and probably reappear near Glyn-Wallis (p. 156). But some sandstones which shut in the hollow to the south can be seen near Llanedy church to lie much above the shales of Glyn-Wallis. We infer, therefore, that the hollow marks the course of an east-and-west fault with a downthrow south. Passing eastwards along this fault we find an ascending sequence on its north side, but a descending one on the other, and its throw consequently dies away. At the same time surface-evidence of it ceases. On the other hand for the same reasons the fault rapidly increases westwards but is soon lost beneath the drift of the Gwili valley.

At Tre-neddyn there is another hollow in line with that at Gwal-yr-hwch from which even more water issues and in the two sides of which also the beds are discordant. It probably marks the course of a fault which cannot, however, be traced far west of the farm. The chief fault must pass along another hollow south-west of this. For strata lying at least 300 yards above the base of the Pennant as shown by the outcrop of the latter at Pen-twyn about three-quarters of a mile to the north-west, are brought into juxtaposition with the supposed base itself south of Tre-neddyn, and the only position we have been able to find for a fault of such magnitude is in a hollow south-west of the farm. That a fault probably passes along this hollow is shown by the abrupt ending on its southern side of a bold feature due to a thick sandstone low down in the Pennant Series. Westwards the fault accounts for this base coming to the surface at Efail-wen; beyond this its course is described on p. 163.

The sandstone above the upper coal at Efail-wen is well displayed in a gorge to the south, where part of it is coarse-grained and contains coal-fragments and clay-pebbles. It is succeeded by shales which are here insignificant but are apparently much thicker less than a mile to the north-east, where they include also a thin coal. Above the shales are sandstones, with subordinate shales and smuts, exposed in the dingles below Ystlys-y-coed-isaf and Efail-wen. The thickest shale with the succeeding sandstone forms a bold scarp between the Gwili and Morlais rivers east of Cil-Dewi-fawr, and at Allt-fawr near the Gwili contains a thin coal with sandstone roof.

We have assumed that in passing from Tre-neddyn to Allt-fawr we cross the same outcrops as in passing from Efail-wen to Allt-fawr, but there is no doubt that in the former case we cross a much greater thickness of beds. This could be explained by a fault with a downthrow east passing along a drift-filled hollow between the two outcrops, and, as a fact, the Pen-lan Fault, described on p. 166, ranges in the right direction. But no evidence of it has been obtained over the intermediate ground and we incline to think that it has died out.

Sandstone crowns the shale-scarp mentioned above and in places, although of fine grain, contains many clay-pebbles, as may be seen in a quarry 600 yards north-west of Allt-fawr.

Westwards the measures below this sandstone are thrown against a series of sandstones with occasional shales by a fault which passes by Pant-yr-yn (1½ miles south-south-east of Llannon) and is exposed in the west bank of the stream south of the farm. A seam said to be 2½ feet thick has been worked at Llwyn-tew, half a mile north-north-west of Cil-Dewi-uchaf, but it does not correspond in mode of occurrence with the Efail-wen vein and consequently the whole of these sandstones have been referred to the Pennant Series. Therefore we infer that the Pant-yr-yn fault has a westerly downthrow.

To the north the sandstones are cut off by the Pont Morlais Fault which is evidenced in this neighbourhood chiefly by the difference between the structures on its two sides. To the north are gentle folds running rather north of west parallel to the fault, while to the south the shales are horizontal or dip steadily southeastwards. The position of the fault is indicated by wet ground and change of slope westwards of Efail-wen (p. 162) to Pont Morlais, beyond which it follows the Morlais as far as its junction with the Llannon disturbance. Its probable connection with this fault has been previously described (p. 158).

The next north-north-westerly break beyond the Pant-yr-yn fault lies along the Morlais Valley and is probably a southerly continuation of the Dynant Fault (p. 179). To the west are sandstones somewhat higher in the series than those on the east, as may be gauged from their distance above the base of the Pennant in the Cockpithall inlier (p. 158). This base is also reached at Maes-llydan, half a mile east of Myrtlehill, where what is evidently the Cockpithall vein has its main crop and is recognised as the Brondini Vein though separated from the outcrop of that vein at Myrtlehill, described on p. 160, by the Llannon disturbance. This fault, west of the valley below Nant-garedig, mentioned on p. 158, continues along another in the same line, but draining west-south-westwards. North of Maes-llydan it breaks through the Brondini Vein, and there it appears to be an overthrust. For the coal, as is shown by old workings, crops above the stream on the south-east bank, but appears to lie some depth below it in the north-west bank, the relative positions indicating that the fault causing the displacement is an overthrust with a north-westerly downthrow.

Here the evidence ceases along the direct line, but a row of springs and an abrupt change of ground suggests that the disturbance continues to the edge of the map along a parallel line lying about 200 yards away on the south.

An upper vein separated from the Brondini Vein by shales, and in places by thin sandstones, has been worked along the main crop and near Cockpithall (p. 160), but in a trial-slope near the west end of the inlier it showed merely partings of coal, one or two inches thick, in shale. Above this vein there are Pennant sandstones, quarried near Gelli-galed, and again at Gelli-gwernen where they become unusually thick-bedded and fine-grained. Near this place, also, they contain in a band of shale a thin coal which may be the same as one cropping near Cil-Dewi, half a mile to the north-northwest.

E. E. L. D.

West of the Loughor Valley—cont.

(2) *Southern part of the Pennant Tract.*

The easternmost of the series of faults which commences with the Loughor Valley ranges up from Gorseinon (in Sheet 247), where it has been proved in the Six-feet Vein to be a downthrow west of 75 yards. The fault-rock can be seen in the quarries on the west side of the road at Bolgoed, together with a small subsidiary fault with a downthrow to the east, and the fault is visible at times in the bed of the Dulais south-south-west of Dan-y-twyn. To the south of the Dulais its effect in cutting off the massive sandstones of its eastern side is most marked, but north of the river it passes under a gravel-flat and is difficult to locate. The throw, however, can be approximately estimated as follows. The Graigola or Six-feet Vein crops at Tan-y-graig, and may be expected to crop not far from Dan-y-twyn or the east side of the fault. On the other side the Swansea Four-feet Vein has been reached at the West Merthyr Colliery, Pontardulais, at 85 yards depth, and may be assumed to crop nearly opposite Dan-y-twyn. The throw, therefore, is about equal to the distance between the Four and Six-feet Veins, or somewhat over 200 yards.

The identification of the coals at once becomes difficult. To the west of this fault the crop of the Graigola Vein must of course be shifted northwards, and is believed to have been found at Tal-y-fan in 1877.* The seam here proved was 3 feet 9 inches thick, but devoid of parting, representing the top only of the Graigola of Birch Rock, which is divided by a 'pinching' into a top and bottom coal.

The slant was carried some 100 or 200 yards nearly down the dip in a south-westerly direction. Levels on the west side met a clean face of rock at about 30 yards distance from the slant, evidently a fault which diverged slightly from the slant towards the south. At the end of the slant a fault was met which appeared to curve round eastwards and cut off the coal, introducing ground so rotten that it was unsafe to work it. At the end of the slant a fireclay appeared to run up at an angle of 45° as though to an upthrow south, but in a working a few yards east of the slant the fault appeared to be an upthrow the other way. A borehole to a depth of 60 or 70 yards proved shale in a healthy condition, but no coal. A trial-pit in a field north of the slant was sunk to a depth of 22 yards and proved a coal 22 inches thick, which it was thought might represent the Two-feet Vein of Swansea. This description suggests that there may have been an east-and-west overthrust passing between Tal-y-fan and Ty'n-y-bonau, in addition to the fault proved on the west of the slant, and to the Gorseinon Fault which appears to range a few chains to the east of it. The absence of any known crop for the Five-feet Vein may be attributed to the highly disturbed state of the ground between Tal-y-fan and Ty'n-y-bonau, as proved in the slant.

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* For the account of these workings I am indebted to Mr. Daniel Evans,

Crossing now to the west side of the Loughor we find a vein being worked at Fforest and cropping close to Pontardulais Bridge. The coal is 2 feet 6 inches to 2 feet 9 inches thick and is considered to be either the Swansea Five-feet or Six-feet Seam. To the south of it there crops out a massive sandstone which is quarried at Hendy, but all other overlying rocks are concealed by gravel and alluvium. To the north there rise from beneath it the sandstones and shales of Fforest and at their base a group of thin seams which have been worked round the northern slope of the hill covered by Fforest Plantation (p. 156). These might represent the Six-feet, Three-feet and Two-feet, if the Fforest seam is the Five-feet, but the identity of that seam with the Six-feet is more probable.

If now we consider the relative levels of these veins with those of Tal-y-fan and West Merthyr we find that a large easterly downthrow must intervene. The supposed Six-feet of Fforest, for example, is approximately on a level with the Penyscallen of Pontardulais (p. 172), from which the throw of the fault may be inferred to be about 280 yards. At the Mountain Slant, in Sheet 247 and about three miles to the south, the throw of the fault has been proved to be 333 yards.

The fault thus inferred may be supposed to run near Pontardulais Bridge and along the Loughor towards Llanedy. It helps to account for the form of the valley, which is unusual in respect of the facts that it is broad, and that it is divided into two branches by the rock-hills of Tal-y-fan and Ty'n-y-bonau. The Loughor runs on the west side of these hills, but there is an almost equally deep and broader depression on the east side. The two depressions correspond locally to, and no doubt have been determined by, the two faults described above. Southwards the more western of the two ranges for Waun-gron, where there is evidence of disturbed ground, though it has not been reached in the workings of the Grovesend seams (Sheet 247) at that spot.

The supposed Swansea Six-feet Seam dips south-west at 6 inches to the yard, and crops all along the north side of the hill north of Hendy to Felin Fforest, with a slight interruption only south of Fforest, where it is crossed by a small easterly downthrow. A few yards below it on the west side of this fault there lies a hard quartzitic sandstone in much request as road-metal, and seen to a thickness of 12 feet. Though conspicuous here, this band is not known elsewhere, and is therefore useless as a means of identifying the seam. It resembles 'cockshot' rock (p. 94).

In the Gwili Valley, which bounds the tract last described on the west, we find evidence of a second large easterly downthrow. To the west of that valley the nomenclature of the seams as used at Swansea is replaced by that in use at Llanelly. The following list shows the equivalent names:—

Llanelly.	*Swansea.*
Box Big, or Six-feet Vein.	Four-feet or Wernffraith Vein.
Four-feet Vein.	Five-feet Vein.
Fiery Vein.	Six-feet or Graigola Vein.
Golden Vein.	Three-feet Vein.
Bushy Vein.	Two-feet Vein.

The Golden Vein (Swansea Three-feet) is being worked with its underclay at the Tal-y-clyn Brickworks, while the Fiery (Swansea Six-feet) and the Swansea Five-feet have been proved in their proper relative positions, the Swansea Five-feet having been worked by a slant 350 yards south of Tal-y-clyn-uchaf. Lastly the Bushy Vein, the lowest of the group, is said to have been seen at its proper distance below the Golden Vein. The identity of these veins therefore is established by strong cumulative evidence.

But on comparing the two sides of the Gwili Valley we find that the crop of the Six-feet on the western side is about 1000 yards further south than it is on the eastern side. Assuming the dip to average 6 inches to the yard, that displacement implies a vertical shift of about 166 yards. If, as has been suggested, the Fforest seam is the Swansea Five-feet, the shift would be 290 yards, while that of the fault at Pontardulais Bridge would be 100 yards less than the estimate given above.

The fault to which this effect is attributed has not been proved underground anywhere, but is said to have been seen in the yard of Tal-y-clyn-uchaf. Thence it runs under some unsound ground on the west side of the Gwili, keeping clear of the rock exposed in the river for about half-a-mile north of Felin Fforest. Its southward course is discussed in the part of this Memoir description of Sheet 247.*

The next and third of this series of easterly downthrows has been proved in the Morlais Colliery to have a throw of 45–50 yards.†

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* 'The Country around Swansea,' 1907, p.116. *Mem. Geol. Survey.*

† Information from Messrs. Thos. Williams & Sons.

The fault runs 150 yards east of the shaft and breaks through the crop of the Five-feet Vein close to Pen-lan. Thence northwards its course is obscure, and it probably dies out.

The Morlais Colliery is situated between the last-described and the next of the series of easterly downthrows, a tract nearly one mile broad. The shaft was sunk on the crop of the Box Big (Swansea Four-feet) Vein and reached the Swansea Five-feet at 108 yards depth. The Five-feet Vein was proved again on the west side of the fault in a trial-pit 350 yards south-south-east of Pen-lan at a depth of 14 yards, in the Tyr-fernel Colliery at a depth of 23 yards and in a level and shaft at Tir-Eglwys, close to its crop. The Fiery, Golden and Bushy Veins crop out a little further north, but have been little worked. The Fiery is said to be 3 feet 3 inches thick, and the coals are reported to be bastard anthracites, that is intermediate between steam-coals and anthracites.

A small seam has been opened in a level 100 yards north of Old Goitre, and about 550 yards north of the crop of the Bushy Vein. The level shows a sandstone-roof resting on one foot of coal. This appears to be one of the unimportant nameless coals which occur at intervals in the Pennant, below the recognised seams of the Swansea and Llanelly districts.

This brings us to the fourth of the series of easterly downthrows, or the Plâs-isaf Fault. In the adjoining area on the south (Sheet 247) the downthrow amounts to nearly 200 yards. The fault is well exposed in the Morlais 400 yards above Llangennech Mill and runs thence along the eastern side of the Morlais Valley, cutting off the range of coals described above. Here it brings the crop of the Box Big Vein face to face with an old level on what we suppose to be the Bushy Vein, which implies a throw of more than 230 yards, but further north its position and even its existence become doubtful. A small branch from it was reached in the Five-feet workings from Morlais and was noticed in the mouth of the Tir-Eglwys level.

To the west of the Plâs-isaf Fault the crop of the Swansea Five-feet (here known as the Llanelly Four-feet) is conspicuous on Allt, but the seams below it are not definitely recognised. A small vein, reputed to be 2 feet 6 inches thick and very sulphury, has been worked through Troserch Wood and at Troserch-fâch ; this may be the same as the little seam of Old Goitre, already mentioned. A fault passing under Corn-hwrdd and believed to be continuous with the Dynant Fault is a downthrow west and forms a curious exception to the long succession of easterly downthrows of this region. The crop of the Swansea Five-feet (Llanelly Four-feet) runs on the western side of the fault from Corn-hwrdd to Clyn-gwernen without interruption. At Porth-Dafen, 900 yards north of the Corn-hwrdd Colliery a slant was being opened in 1902 on the crop of the Golden Vein and had proved it to be a dry steam-coal, 20 inches thick. The Bushy Vein had not been found but was supposed to crop about 90 yards further north again. The

Fiery Vein is supposed to crop in a steep brow 500 yards N.N.W. of Corn-hwrdd Farm. Lastly a seam, said to be about 11 inches thick, has been worked on either side of the Dafen River at Allt-y-fran-fawr. If, as seems likely, this corresponds to the Troserch seam, it furnishes further evidence of the position and westerly downthrow of the Corn-hwrdd Fault, for the horizontal shift of the outcrops amount to about 700 yards.

The dip in the ground described above ranges from 13° to more than 20° in a southerly and south-easterly direction; all up the Morlais Valley, for example, to Cil-Dewi a southerly direction prevails, but at Blaen-hiraeth and on both sides of a swampy valley west of it the dip is eastward. The connection between this structure and the fault is not obvious, for on the supposition that the fault is passing northwards into a uniclinal fold, the dip should have been west. The valley, however, is assumed to mark the position of the fault. It is not an ordinary stream-valley, in as much as the drainage along it runs partly northwards to the Morlais and partly southwards to the Dafen, a small peat swamp forming the actual water-parting; but on the other hand it does not divide the eastward-dipping from the southward-dipping strata, for Blaen-hiraeth stands on a ridge of sandstone dipping east, as though the main fault might be still further east.

The fifth of the series of easterly downthrows is known as the Bryn-serfyll Fault, and has been found in all the seams from the Llandilo branch of the Great Western Railway (Sheet 247) as far north as Clyn-gwernen where it cuts the outcrop of the Five-feet (Llanelly Four-feet) Seam. Farther north, though not actually visible, it is believed to run up a dingle to the Llanelly and Llandilo road and to pass about 300 yards west of Clochyrie. Near Dafen (Sheet 247) its throw is reckoned to be about 245 yards, but it seems to diminish and die away northwards.

From the Bryn-serfyll Fault to the Box Fault, the next of the series of easterly downthrows, is a distance of more than a mile with no fault of consequence. The Fiery and Golden Veins were worked east of Felin-foel (Sheet 247) and the crop of the Bushy Vein was proved at a point 300 yards east-south-east of the church. Below this again in the Lliedi Valley some small veins which have been worked at Cille near Llanelly make their first appearance. The highest, Cille No. 1, has not been recognised in the Lliedi, but what is supposed to be Cille No. 2 has been worked by a level 350 yards N.W. of Felin-foel Church and on the east side of the valley, 400 yards N.E. of Lan. Cille No. 3 crops out in a wood on the west side of the valley 300 yards below the lower Lliedi reservoir. They are reported to be steam-coals, but are of little value.

Except for these seams and some shaly bands the sides of the valley from Felin-foel to the head of the reservoir show little besides massive Pennant, dipping south at 15° to 25°. The distance from the crop of the Bushy Vein in Felin-foel to the last exposure of rock is 2,170 yards, and assuming an average dip of 20° we find here indicated a thickness of about 730 yards of measures. Allowing 290 yards for the distance from the Bushy Vein to the Box Big (Swansea Four-feet) Vein, we thus get in round numbers 1,000 yards as the total thickness of the measures which successively rise from beneath the top of the Pennant along the Lliedi. But it will be remembered that in Graig-fawr to the east of the Loughor (p. 154) we got an estimate of about 900 yards as the thickness of the whole Pennant series, taking the Swansea Four-feet and Garn Swllt Vein as the top and bottom respectively of that series. We should expect therefore to find the base of the Pennant in the Lliedi near the point where the above estimate ends. The estimate ends with the rock which crops under Ystrad-fai, but in excavating for the foundations of the dam of the upper reservoir a little further up, a coal was found, associated with a siliceous rock of unusual purity for Coal Measures. The coal seems to be the same as the vein worked at Trefanau half a mile to the west, and this again we believe to be the same as the Gyscwm of the Pembrey district, which on other considerations we have taken to represent the base of the Pennant. On these grounds the base of the Pennant has been drawn in the Lliedi Valley at the Trefanau Vein. An independent estimate of the thickness of Pennant below the Bushy Vein will be found on p. 161. The estimate gives 2,300 feet as the thickness below the Golden Vein, which lies 34 yards above the Bushy. We get, therefore, 733 yards below the Bushy in the one case as compared with 730 yards in the other. So close an agreement where precise data are lacking is accidental.

The Box Fault, or Box Great Bar as it was called by the old miners, forms the sixth of the series of easterly downthrows. Near Box (Sheet 247) it has a throw of about 150 yards, but like all the others it diminishes northwards. For though there are surface-indications of its position for a mile north of Felin-foel, the shift of the outcrops of the Cille Veins is small. A little north of Llwyn-y-piod all evidence of its existence ceases.

On its western side Cille Nos. 1, 2, and 3 have been tried in Cwm Trebeddrod and there is an old pit on the last-named south-west of Yscubor-isaf. No. 1 is said to be 10 inches thick, No. 2, 13 or 14 inches, and No. 3, about the same, with a parting of shale. What is called Cille No. 4 crops a few yards south of Cilau-gwyn where there was a pit upon it, and in the foundations of Ty-llwyd to the east of the dingle, while in the dingle there are old levels upon it. A fifth seam, said to be 12 inches thick, crops south of Pant-y-llydau-fach (Sheet 229), and two more, which appear, however, to be mere smuts, are evidenced to the north and south of Pant-y-llydau-fawr. Next we reach the Trefanau seam already mentioned, and finally a deep hollow, marking the outcrop of some shale with a trace of coal, at Bryn-y-groes-fawr. The last-named, if we are right in identifying the Trefanau seam as the Gyscwm, may represent the Cenrhos of the ground further west. It will be noticed that the veins enumerated above must include a representative of the

Hughes Vein. The position of that vein will be discussed in the account of Sheet 246. It seems probable that it is represented by a seam struck at a depth of 218 yards in the Cille borehole, shown in detail in *Vertical Sections*, Sheet 87, Sect. No. 20, but it is not possible to identify with certainty the seams found in the borehole with the outcrops in Cwm Trebeddrod. There is no doubt, however, that the Hughes group has greatly deteriorated in value in this part of the coalfield.

The east-and-west fault shown on the map as crossing the Lliedi north of Gelli-lysged must be mentioned here, though its effects are more fully displayed in the adjoining map (Sheet 229). A southerly dip, as already mentioned, prevails along the Lliedi to Trefanau and for 800 yards north of it, but the inclination steadily increases from about 12° near Llanelly to 30° at Trefanau, and to 48° near the fault. On the line of the fault as shown there runs a hollow yielding no exposure of sound rock but suggestive of broken ground; while a few yards to the north of it the strata as seen in the Lliedi dip gently northwards. The fault, therefore, coincides with an anticline, steep on its southern side and gently inclined towards the north. About 500 yards further north a southerly dip sets in again. Eastwards we get no evidence of either fault or anticline, but westwards they develop into a disturbance of great intensity which runs by Trimsaran towards the coast. At Trimsaran the general effect of the disturbance seems to be a downthrow north, but generally speaking it may be described as a belt of contortion and overthrusting, and like other disturbances of the same character is likely to vary rapidly in amount and direction of throw. An interesting little overthrust connected with the disturbance is exhibited in a dingle 600 yards south of Horeb (Sheet 229).

A. S.

CHAPTER X.

CARBONIFEROUS ROCKS (*continued*).

COAL MEASURES (*continued*).

UPPER COAL SERIES.

By A. STRAHAN.

The base of the Upper Coal Series is drawn at the seam known in various parts of the district as the Wernffraith or Primrose (Neath), the Four-feet (Swansea), and the Box Big or Six-feet Vein (Llanelly). The northern margin only of the tracts occupied by these measures fall within the map under description.

The Dyffryn Trough.

The Primrose Vein was reached at a depth of 14 yards in the shaft of the Cwm-nant-llwyd Colliery (*Vertical Sections*, Sheet 87, No. 1) and consisted of two coals 3 feet 9 inches and 3 feet thick respectively with 3 feet 9 inches of parting between them. In the workings, however, an average section showed coal 2 feet 9 inches, clod 4 to 5 feet thick, and a lower coal 1 foot 8 inches, which was left. The crop runs close to Gelli-ceirios and Cil-y-bebyll, where a sandstone, believed to lie above the coal, is visible.

The measures above the seam are seldom exposed to view. The Clydach exhibits sandstone from near Hendre-lâs to Ty'n-y-cwm, but the shaft of the Main Colliery (Sheet 247), which is shown in detail in *Vertical Sections*, Sheet 87, No. 3, proves that shales and clays predominate above the Wernffraith, whereas sandstone is almost continuous below it. The shaft shows also the position of the Bryncôch Seam, 152 yards above the Wernffraith. No other seams have been worked in the Upper Measures of this trough. The trough as elsewhere explained lies between the Rhydding Fault, a downthrow west of 500 to 800 yards, and the Dyffryn Fault, a downthrow east of 240 to 440 yards. The measures thus troughed in dip south-east and have yielded a large quantity of coal. The faults shown on the map were found in the Wernffraith and Graigola Seams. They are downthrows west and run into the Dyffryn Fault at no great depth.

The Lliw Valley.

The boundary of the Upper Measures along the south side of this valley near Felindre is wholly conjectural. The Four-feet (Wernffraith) Vein was worked in the Rhyd-y-pandy syncline at

Bryn Whilach (Sheet 247), and was followed a short distance up the northern rise, but not nearly to its crop. On the other hand to the north of the valley there are long dip-slopes of sandstones which appear to be below the vein. A conjectural crop for the vein has, therefore, been drawn between these two regions, and on both sides of the Rhyd-y-pandy syncline further east as described on p. 151.

At Cil-yr-ystarn south-east of Bolgoed a shaft was sunk 21 yards to a seam which was considered to be the Four-feet and a little coal appears to have been raised. The seam occupies about the same position relatively to the sandstones of Bolgoed and Bryn-bâch Common as the conjectural crop holds to the dip-slopes mentioned above.

The Loughor Valley.

The Bolgoed or Gorseinon Fault throws in a tract of the Upper Measures containing representatives of the veins proved in ground further south near Loughor (Sheet 247). The shaft of the West Merthyr Colliery, 520 yards E. N. E. of Pontardulais church, proved the Loughor Little Vein at 61 yards and the Four-feet (Wernffraith) Vein at 80 yards depth. The measures dip a little west of south at 1 in 6.

West Merthyr Pit, Pontardulais.

Communicated by Mr. William Price.

		Thickness. Yds.	Ft.	In.	Depth from Surface. Yds.	Ft.	In.
Shale with a rider *		60	0	0			
Rock		0	2	0			
Coal [Loughor Little Vein]		0	1	1	61	0	1
Shale and rock		18	0	0			
Swansea Four-feet Vein.	Coal	0	1	10			
	Rashes	0	0	8			
	Coal	0	0	8			
	Not described	0	1	3			
	Coal	0	1	0	80	2	6
Rashings		3	0	0			
Rock		0	2	0	84	1	6

The Four-feet Vein is supposed to crop towards the northern margin of the gravel-flat of the Dulais. The Penyscallen Vein is believed to come to the surface somewhere north of the church, while lastly an old slope has been recently opened on what was thought to be the Stinking Vein, but is now believed to be the Upper Gelli Vein. The seam is worked as a steam-coal and consists of the following bands :—

Upper Gelli Vein.

	Ft.	In.
Top coal	0	5
Clod	1	0
Coal	1	2
Clod	0	5
Coal	0	6

---

* This rider crops out at the foot of the hill, a few yards north of the shaft.

The position of the Four-feet Vein between the Pontardulais and Gwili Faults, described on pp. 165–166, is wholly conjectural. It is calculated on the supposition that the vein worked near Fforest is the Swansea Six-feet, and that a small seam about 4 inches thick, which crops out on the north side of Hendy Village, is the Swansea Five-feet Vein; but neither the crop nor the character of the Four-feet Seam has been ascertained in this belt.

On the other hand the seam has been extensively worked between the Pen-lan and the Plâs-isaf Faults. The dip is only a little west of south on the north side of Llangennech Park, but swings round to south-west, and finally to west nearer to the Loughor, thus introducing on the east (downthrow) side of the Plâs-isaf Fault some of the highest measures existing in the coalfield.

In all the occurrences of Upper Measures described in this chapter we find the same general rule holding, that their outcrop is characterised by low featureless ground, generally overspread by glacial drift or by alluvial flats. The Four-feet Vein marks in a general way the limit of the ground having this character and crops at the foot of long dip-slopes of sandstone. The explanation is to be sought in the difference in character of the strata lying above and below the vein. as proved in the shafts in the Dyffryn Trough.

A. S.

CHAPTER XI.

FAULTS AND DISTURBANCES.

Introduction.

In the region embraced by this map the series of west-south-westerly belts of compression, of which the Neath and Cribarth Disturbances (Sheet 231) form forerunners, reaches a further stage in its development towards the north and west. At the same time the northerly or north-north-westerly faults maintain the frequency and the more or less regular spacing which characterises them through so much of the coalfield, while some of the largest yet met with occur within the region under description. Generally speaking, the west-south-west disturbances may be described as belts of folding accompanied by overthrust-faults with throws varying rapidly in amount and direction; while the north-north-west system consists of normal faults less liable to change.

The relative age of the two systems has been discussed in previous parts of the memoir on the coalfield, but still remains an open question. Not improbably it is incapable of a complete answer, inasmuch as movement has been renewed along the same lines in more than one geological period. Thus we have been able to ascertain, partly here but more certainly further west, that west-south-westerly movements intervened between the Ordovician and Silurian periods, were renewed in the same direction and type between the Silurian and Old Red Sandstone, while, lastly, they were obviously active after the Carboniferous period. Again, the north-north-westerly faults are certainly in places post-Liassic, but that they followed older lines of faulting is proved by the fact that they are generally larger in the Carboniferous than in the Secondary rocks. In these facts, conceivably, may be found the explanation of our difficulties. For there are cases where the faults of the one system seem to cut right through the folds of the other, but just as often the disturbances either terminate or deflect the faults. The marked effect, however, of the west-south-west disturbances on the river-system gives ground for thinking that some of them may have been in operation at a late geological period.

A detailed account of the faults will be found in the parts of this volume descriptive of the stratigraphy, and we propose here only to summarise what we have been able to ascertain concerning them in our respective areas. For this purpose we may deal with the systems under separate headings, for convenience, however, and not thereby implying that they may not be partly contemporaneous, or that they are always of the same relative age.

A. S.

THE NORTH-NORTH-WESTERLY FAULTS.

East of the Loughor Valley.

The existence of a compound downthrow west of 100 yards in Farteg Hill is ascertained without difficulty (pp. 96, 97), but the course of the fault both southwards and northwards is less obvious. Southwards its position is evidenced in the Dulais Valley (p. 141) but is obscure elsewhere. Northwards it is assumed to pass Gyrnos and to be continuous with the fault proved in the Brass Vein workings from Cwm Twrch (pp. 97, 99). There it splits into two branches which pass through the Farewell Rock, both throwing that rock down west.

The Twrch-fechan Fault, a large westerly downthrow, though unknown in the Coal Measures north of Ystradgynlais, can be easily traced on the moorland of Llorfa to the north, and at the mouth of the Twrch-fechan can be located within very narrow limits. At Pen-rhiw-gôch at the head of the Twrch-fechan it breaks down into a group of smaller faults, some with easterly downthrow, which can be clearly traced where they cut the outcrop of the Grey Grits; and a further splitting-up of one of these faults can be seen in the Grey Grits and plateau-beds (pp. 60, 65) north of Careg-yr-ogof in Sheet 212.

A fault with easterly downthrow runs up the Twrch valley west of Dorwen and throws down the Millstone Grit of Esgair-hîr in two steps on the east against the limestone on the west. Opposite Dorwen it throws off a branch with westerly downthrow which crosses obliquely into Nant Llynfell. Between Dorwen and Ffrwd-ar-Dwrch it throws off another branch which runs up the Twrch along the foot of Tyle-garw, and combined with folding introduces the strip of limestone in the bed of the Twrch described on p. 70.

A small downthrow east is visible in the Grey Grits at Blaen Clydach, and farther west there are others traceable in the same beds at Tyle-du and Rhiw-wen.

The Rhydding Fault has a downthrow west of 760 yards in Sheet 247, but diminshes to 595 yards in the Tawe Valley (p. 144). The position of the fault is known exactly as far north as the Tawe, and can be fixed within close limits a mile or two northwards again. The remarkable twist it makes in crossing the Tawe is therefore more than hypothesis.

Under the name of the Cwm-Llynfell or Bryn-llefrith Fault it throws the veins down 190 yards westwards at Cwm Llynfell, and shifts the Farewell Rock at Rhôs-Amman. In the Carboniferous Limestone at Rhiw-wen its throw is not less than 150 yards.

The Dyffryn Fault, like the Rhydding Fault, attains its maximum (440 yards) in Sheet 247, and diminishes in the Tawe valley (p. 145). Being a downthrow east it co-operates with the Rhydding Fault in throwing down a trough, which, with remarkable regularity, runs for about eight miles, and maintains a breadth of about one mile. The trough reaches its greatest depth near Bryn-côch (Sheet 247) and gets shallower thence both to the north and south. Thus the Dyffryn Fault produces little if any throw north of the Egel, though the more powerful Rhydding Fault runs on for several miles further under the name of the Cwm-Llynfell Fault (p. 104).

The twist made by the Rhydding Fault in crossing the Tawe Valley has already been noticed. The Dyffryn Fault makes a precisely similar twist and thus maintains its parallelism with the Rhydding Fault. The result is that the trough as a whole is twisted in crossing the Tawe, and though it runs almost due north and south on either side of the Tawe, the two parts are nearly one mile out of line. The meaning of this structure will be best discussed in connection with the disturbance which we believe to underlie the Tawe Valley (p. 181).

The Brynamman Fault has a downthrow west. It has been proved in the Coal Measures (p. 06), shifts the outcrop of the Farewell Rock, and at Breast Cwm Llwyd has a marked effect on the Carboniferous Limestone which it throws down west about 200 yards. It thus shows a rapid increase of throw northwards. Its effect in the Old Red Sandstone is not easily traced, but it appears to break the base of the Brownstones.

A large easterly downthrow can be traced in the Millstone Grit in Cwm Pedol; it crosses Tair Carn Uchaf and breaks the outcrop of the Carboniferous Limestone south of Blaen-Cennen. South of Banc Wern-Wgan two small westerly downthrows cut the base of the limestone.

The Ty-llwyd Fault—a westerly downthrow, well marked in the Coal Measures of Cwm Amman (p. 110)—crosses the south-west end of Tair Carn, and splitting to let in a wedge of Millstone Grit at Llygad Llwchwr throws down the base of the Limestone for some 200 yards.

An easterly downthrow appears in the Millstone Grit at Forge Llandyfan, passing through the gap at the eastern end of Careg-y-Dwfan; its throw in the Limestone must amount to about 120 yards. On its eastern side it has contributed to preserve a small outlier of Coal Measures (p. 112).

The Gardener's Fault receives this name in Sheet 247, where it is a downthrow west of nearly 300 yards. Its throw on the north side of the Tawe has not been proved, but may be estimated in round numbers at 200 yards where the fault passes between the outcrops of the Hughes and Graigola Veins (p. 149).

In the north crop it splits temporarily into the two branches, known respectively as the Nant Garenig and the Glyn-môch Faults, both downthrows to the west (p. 111). At the south-west end of Tair Carn it can be clearly traced, where it throws down Coal Measure shales on the west against the basal grits of the Millstone Grit on the east, and can be closely located in the Coal Measures at Dre-fâch on the Loughor. At Llandyfan, where it crosses the escarpment in a characteristic gap, it brings the top of the Limestone on the west almost opposite the base on the east, which indicates a throw of about 230 yards. It also breaks the outcrop of the Senni Beds but is lost in the Marls. A little to the west of it a small parallel fault is visible in the Garn-fâch limestone-quarry at Llandyfan (p. 73).

The Gardener's Fault is followed by a series of westerly downthrows, some of which have been proved in the Graigola workings to range up to 40 yards in throw, but the fault which passes by the Felindre Colliery, and which there splits into two branches, has not yet been touched (p. 152). Of all these two only continue to the North Crop, namely the Gardener's Fault as already described, and the western branch of the Felindre Fault which becomes the Bettws or Dinas Fault.

The effect of the Bettws Fault on the measures of the North Crop is described on p. 117. Northwards it is doubtless continued in the Dinas Fault, the course of which, through the Millstone Grit and limestone, is clearly defined. It is a large downthrow west, but at Pentre-gwenlas gives off a branch with easterly downthrow which runs along the western crag of Dinas. The main fault runs through the gap at Pant-y-llyn, where the throw must amount to some 120 yards.

West of the Loughor Valley.

In the Loughor Valley there commences a series of faults which as yet are imperfectly known. The Gorseinon Fault passes by Bolgoed and obliquely across the Loughor, and is the last of a succession of downthrows west. Then follows an equally remarkable series of seven great easterly downthrows (including the Stradey Fault in the adjoining map), broken only by one small westerly downthrow. These faults, a description of which will be found on pp. 164–9, characterise a tract of ground about 6 miles broad. We have then this remarkable fact, that from the Gardener's Fault to the Loughor, in a distance of 6 miles, the faults are all downthrows to the west, whereas in the next 6 miles, they are all, with a trifling exception, downthrows to the east. How far this may be regarded as an example of troughing on a great scale it is perhaps immaterial to enquire, but its effect in introducing some of the highest measures in the coal-field in the adjoining ground on the south (Sheet 247) is of more consequence.

These easterly downthrows, however, though large, do not persist far. All die out at about 3 miles distance from the point of maximum throw. Some powerful disturbances range in a west or west-south-westerly direction across the Pennant tract of Llanedy and Llannon, and none of the easterly downthrows can be traced past the disturbed region. More than this, though to the north of the disturbance there are numerous north-north-westerly faults in about the right range, all of them are downthrows to the west.

The Gorseinon Fault, which was proved at the colliery of that name (Sheet 247) to be a downthrow west of 75 yards, ranges past Bolgoed and under the eastern part of Pontardulais, where its position can be determined, and its throw estimated to be about 200 yards (p. 164). From the Dulais northwards it has never been proved unless it was touched at Tal-y-fan (p. 165).

The Hendre Fault is a downthrow west, as is evidenced by its displacement of the Pennant base at Erw-wastad, and may therefore be a continuation of the Gorseinon Fault. Farther north, at Pen-y-groes, it divides the Cae'r-bryn coal-workings on the east from those of Emlyn on the west, and is supposed to be a downthrow west of 90 or 100 yards; but the actual amount of throw has never been proved. What is probably a minor parallel fracture of 21 yards down west has been proved in the easternmost Emlyn workings.

A fault with a small westerly downthrow traverses the Millstone Grit and Carboniferous Limestone from the west of Glyn-yr-henllan on the south to Carmel on the north, and displaces the outcrops 50 yards, which indicates a vertical throw of about 33 yards.

Nearly in line with the Gorseinon Fault there is a fault passing up Glyn-Wallis (p. 155), with a downthrow east, amounting probably to 150 yards. Northwards the throw rapidly decreases, and at Pentre-hardd the fault has a downthrow west of about 200 yards. It is improbable that the Gorseinon Fault is continuous with the easterly downthrow in Glyn-Wallis.

The fault passing under Pontardulais Station (p. 165) is a downthrow east of 280 yards, as estimated from the relative positions of the supposed Swansea Six-foot seam at Fforest and the Four-foot at Pontardulais (p. 172). Presumably it passes up the Loughor to the west of Tal-y-fan, but it has never been touched underground.

It is improbable that this fault passes between Llanedy and Fforest, and the only fault nearly in line with it is a downthrow west, which starts on the north side of the Pont Morlais disturbance and ranges to Bryn-gwili near Cross Hands (pp. 156, 162).

The Bryn-gwili Fault at Cross Hands (p. 133) probably continues northwards as a westerly downthrow visible in a stream at Craig-y-geifr, where it throws the Lower Pumpquart Vein on the west against the base of the Millstone Grit shales on the east. Farther north it throws the Millstone Grit on the west against Carboniferous Limestone on the east.

Near Trawsdre (-ganol) it shifts the outcrop of the limestone 600 yards. This displacement, however, is partially compensated by the Tumble Fault farther west, which has an easterly downthrow and shifts the outcrop a distance of 250 yards in the opposite direction. The throw of the first fault must be about 330 yards and that of the second some 150 yards (p. 78).

The Gwili Fault, the next of the easterly downthrows, passes up the Gwili Valley by Tal-y-clyn-uchaf to Ty'n-y-waun (p. 166). Though a throw of about 166 yards near Tal-y-clyn, it cannot be traced beyond the east-and-west disturbance (p. 163). The only fault nearly in line with it on the northern side of that disturbance is a downthrow west which runs by Dyrclawdd (p. 157). The Pen-lan Fault is described on p. 166.

The Plâs-isaf Fault ranges up the Morlais Valley, but though it is a downthrow east of over 200 yards near Llangennech (p. 167), it has not been identified for more than a mile and a half. A fault at Pant-yr-yn, which is not far out of line with it, is a downthrow west (p. 163).

To the north of the Pont Morlais disturbance the Tumble Fault is the only one nearly in the right range for the Plas-isaf Fault. This is a large easterly downthrow in the lower measures (p. 135) and breaks through the Millstone Grit at Foel Gastell. Acting in conjunction with the Bryn-gwili Fault it throws forward a triangular patch of limestone at Trawsdre, and effects a vertical shift estimated at 150 yards as mentioned above.

A fault at Banc-y-Mansel throws the Millstone Grit and Carboniferous Limestone down west about 90 yards. Southwards it ranges towards Tre-fâch, but it has not been recognised in the Coal Measures.

A small fault with a downthrow west in the Llanelly Four-root Vein at Corn-hwrdd is believed to run by Blaen-hiraeth (pp. 167, 168) and to gain strength northwards. If it does so it falls into line with a fault which follows a well-defined course past Gelli-gwernen and is visible near Coed-cyw Mill. Here it cuts through some flexures connected with the Llannon disturbance in a manner to suggest that it is of later date. It is noteworthy that it is the only fault which can be supposed to cross the Pont Morlais disturbance; in no other case are faults with similar downthrows found in corresponding positions on the two sides of that and the Llannon disturbance. Northwards it follows the Morlais, and at a distance of three-quarters of a mile from the mill has a westerly downthrow estimated at 300 yards (p. 160).

Northwards, to the east of Pen-llwyn, it has a throw of about 80 yards. Still farther north it breaks through the cockshot-rock at Bryn-gwnen, and under the name of the Dynant Fault was proved at the Dynant Colliery in the Big and Green Veins, and at Clyn-hebog Colliery in the Lower Pumpquart Vein. Beyond this point it can be traced in the Millstone Grit and Carboniferous Limestone, but its throw rapidly decreases and it appears to die out in the Old Red Sandstone.

The Bryn-serfyll and Box Faults (pp. 168, 169) both fail to cross the Pont Morlais disturbance, nor is there any fault to the north of it nearly in line with them. The Bryn-serfyll Fault is believed to run along a broad water-logged hollow through the Cockpithall fold, as though it were, like the preceding fault, of later age than the fold, and than the Llannon disturbance of which the fold forms part (p. 158). The evidence, however, is far from conclusive, as the same effect might be produced if the fold were later than the fault.

In the Silurian and Ordovician Tract.

Numerous faults cut through the Tilestones south-east of Llandilo. As the beds are nearly vertical and are sometimes horizontally shifted as much as 100 yards, the faults appear to have a large throw; but it is perhaps more likely that the direction of movement was more or less horizontal.

Near Meusydd-hirion on the east side of the Cennen Valley, a fault shifts the outcrop of the Tilestones about 100 yards to the north on its west side; as the beds dip at 70° to the north this implies a large easterly downthrow. It similarly throws the crop of the Lletty Grit, but the shift of the Silurian base is purely hypothetical. Near Glan-Cennen Farm it appears to split into two large easterly downthrows, which carry the outcrop of the Ffairfâch Grit in two stages from Glan-Cennen Farm to Pen-coed Farm, west of Ffairfâch.

On the west side of the Cennen Valley a fault cuts the Tilestones and Lletty Grit north-west of Rhyd-y-ffynnon Farm, and at Garnwen Farm seems to cut through the lower limit of the Silurian rocks, and also the outcrop of the Ffairfâch Grit.

A small fault crosses the Tilestones a little to the north-east of Caeth-argoed to the east of Golden Grove, producing a horizontal displacement which indicates a westerly downthrow. A fault of much greater magnitude with the normal north-north-westerly direction may be traced from Bryn Martin-uchaf to the Keeper's Lodge at Llanfihangel Aberbythych. It follows the line of the Dinas Fault and may or may not be its northerly prolongation. It is, however, impossible to say whether this fracture crosses the belt of east-and-west disturbance which traverses the middle of the Old Red Sandstone outcrop from Careg Cennen to Bryn-yr odyn. The horizontal displacement of the outcrops of the highly inclined Silurian rocks amounts to 100 or 150 yards. This implies that the movement of the fault was either not in a vertical direction, or that if vertical it must have been on an immense scale.

This fault, although it seems to pass from the Silurian into the Ordovician rocks, and to shift the fault between them, cannot be proved to do so, and this is the case with all the north-north-westerly faults which can be traced into the Silurian rocks from above, and with those which exist in the Ordovician and approach the Silurian from below. A fault is inferred to cross the lower limit of the Old Red Sandstone and enter the Silurian area at a point 250 yards to the west of Cefn-Berach Chapel. On its western side it displaces vertical and highly inclined Old Red Sandstone and Silurian rocks a horizontal distance of 80 yards, while it also throws the Lletty Grit an equivalent amount. Towards the western edge of the map a fault with a westerly downthrow displaces the base of the Old Red Sandstone, and may be traced into the Silurian rocks below, but there is no evidence to show that it breaks their lower limit.

THE WEST-SOUTH-WESTERLY DISTURBANCES.

The Tawe Valley.

The faults by which the outcrops of the lower veins are twice repeated at Ystradgynlais are described on p. 95. They form a direct continuation of the Cribarth Disturbance to the north-east (Sheet 231), but their course to the south-west is less obvious. The disturbance as a whole gains considerable breadth, for the strata cropping in the Gwys (p. 99), and in the lower parts of Cwm Twrch and Cwm Llynfell (pp. 99–103), are clearly involved in it. But these folds soon die away on the south-west, nor is there any sign in the Pennant on either side of the Tawe Valley of folds or faults belonging to the west-south-west system. The question arises, therefore, whether there is a disturbance running down the Tawe Valley under the alluvial flat, as happens in the Vale of Neath.*

The fact that the Red Vein was reached in shafts on either side of the alluvial flat near Ynys-y-geinon Junction (p. 97), at about the relative depths which would have been anticipated from the dip, seems at first to negative the idea. But there are other circumstances which strongly suggest a disturbance. In the first place the valley is a deep narrow trench of remarkable straightness, in line with and following the direction of the Cribarth Disturbance. In these respects it compares well with the Neath Valley, but differs from that of the Loughor, where no such disturbance has been found to exist. In the second place the Rhydding and Dyffryn Faults suffer the remarkable deflection described on p. 176, in crossing the valley. Some slight deflection of the same kind can be noticed in the Gardener's Fault also (Sheet 247). Lastly there is the fact that the crops of the Hughes Vein on either side of the valley, both above and below Pontardawe, do not match (p. 145). Southwards the same line is carried on in the Tir-canol Fault (Sheet 247), while the syncline which crosses Cwm Clydach and ranges under Rhyd-y-pandy (p. 149) may be connected with the same general movement.

Tair Carn.

This compound fold runs in a direction W. 30° S. and consists of a broad anticline with a parallel syncline on its north-western side. The anticline makes its appearance at Tair-carn-uchaf, in the basal grit of the Millstone Grit—that massive rock being bent up into an arch which constitutes the ridge. Not far from the crest of the arch lies the small inlier of limestone referred to on p. 72. South-west of this the anticline is prolonged for over a mile, but south of Dre-fâch the single arch buckles down into two smaller anticlines with an intervening syncline.

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* A. Strahan in 'The Country around Merthyr Tydfil,' 1904, p. 92, *Mem. Geol. Surv.*

The main syncline can be traced in the grit along the south side of Gwythwch Brook through Forge Llandyfan to Dre-fâch on the Loughor, along which line lie the little Coal Measure outliers described on p. 112.

Half-a-mile south of Forge Llandyfan a subsidiary anticline at Thornhill between the main anticline and syncline brings up the basal grit through the shales of the Millstone Grit. A north-north-west fault here appears to cross the west-south-west fold.

In the Coal Measures west of the Llandyfan Fault the detailed structure of the disturbance is not easily traceable, but the vertical and highly-inclined Coal Measures in the Loughor west of the fault lie on or near the axis of the main syncline, while the position of the main anticline may be inferred from the approximate horizontality of the Coal Measures in the Glyn-hîr gorge and from an anticlinal outcrop of the Farewell Rock in Glyn-hîr Park.

West of the Llandybie Valley the complicated series of folds and overthrusts in the Coal Measures of the Llandybie and Llannon districts lies on the same line of disturbance and may be regarded as a continuation of the same belt of folding. These disturbances have been already described in the pages dealing with the Coal Measures.

It is sufficient here to mention the overthrust met with in the Ammanford Colliery (p. 115), and the Pontyclerc overthrust, a downthrow north of some 200 yards (pp. 127, 128). The whole of the Coal Measures west of Ammanford are highly folded, as may be seen from the sinuosities in the outcrop of the Rock Vein rock between Hendre and Cae'r-bryn.

Llannon.

Though more or less in the same general line with the Ammanford overthrust, the disturbances of the Llannon neighbourhood, described on pp. 158, 160–163, cannot be traced continuously to join up with it. The Pont Morlais Fault, for example, commences near Llanedy, crosses the Gwili close to where the Gwili Fault with a large downthrow east gives place to the Bryn-gwili Fault with a large downthrow west, and at the same time itself changes from a downthrow south to a downthrow north. Two large opposing faults such as the Gwili and Bryn-gwili Faults cannot die out close together without the stresses set up thereby being eased by folds or faults in other directions. Adequate folds do not exist and we are driven to conclude that the Pont Morlais Fault was formed at the same time as the others. For the alternative hypothesis, that it was formed either previously or subsequently, introduces great difficulties. The Pont Morlais Fault runs nearly due west, and in that direction joins the Llannon Fault (p. 158). This, running south-westwards, also has a course oblique to the general direction of the west-south-westerly disturbances, but the resultant of the two, after their union, follows an intermediate, normal direction.

A little to the south of the Llannon disturbances there is an anticline, accompanied by crushing and overthrusting (p. 170). It commences between the Lliedi and Morlais valleys and runs westwards to Trimsaran (Sheet 229) where it gains great intensity.

Careg Cennen.

The Cennen Disturbance lies about two miles north of Tair Carn and runs parallel with it. Along the Cennen Valley near Trapp its most marked effect is to throw down into the Cennen Valley the conspicuous outlier of Carboniferous Limestone crowned by the ruins of Castell Careg Cennen (Fig. 10, p. 184).

The disturbance consists of a series of anticlines and synclines accompanied by strike-faults. An anticline is traceable in the Senni Beds from Blaen-Cennen Farm on the east, past Cwm-tawel, as far as Cwm-ffinnant near Trapp. A still better marked syncline partly accounts for the promontory of Senni Beds north of Blaen-Cennen Farm and can be traced south-westwards as far as Parc-Owen. There is some evidence that a fault with southerly downthrow appears in the Senni Beds a little west of Blaen-Cennen Farm, and ranges thence through Clyn-llydan; but it does not become obvious till it crosses the Cennen and forms the northern boundary of the limestone-mass of Castell Careg Cennen, which it separates from the green sandstones of the Senni Beds and the underlying Red Marl on the north. This main downthrow south throws off two branches with downthrow north, the northern of which rejoins the main fault, and thus with it encloses a mass of Brownstones capped by the limestone of the Castle. None of the faults can be traced west of Trapp, but it is not unlikely that one or more of them lie concealed in the outcrop of the Old Red beds, to reappear in the Gwendraeth-fâch Valley as the Bryn-yr-odyn Disturbance.

Bryn-yr-odyn.

A deep depression in the middle of the outcrop of the Old Red Sandstone, occupied now by a peat-bog which was once a *pysgodlyn* or fish-pond, attracts attention by its curious form and depth, suggesting at the same time a fault-valley. Traced westwards the disturbance becomes evident a little to the south-east of Bryn-yr-odyn Farm (Fig. 11, p. 184), where a mass of Carboniferous Limestone is met with (p. 80) on the western side of the road leading to Bryn-du. Here the fault splits into at least two branches, which, after diverging, run parallel to each other for some distance, forming the northern and southern boundaries of the limestone. After crossing the road to Maes-y-bont they gradually approach one another, while a stream-section 100 yards to the west of the road shows that the southern fault has split up in such a manner as to cause a lenticle of vertical Old Red Sandstone, faulted on all sides, to be included in the limestone.

The northern fault may be seen to the west of Bryn-yr-odyn and the southern branch is marked by a belt of crush-rock, well

FIG. 10.—*Section across the Careg Cennen Disturbance.*

BY T. C. CANTRILL.

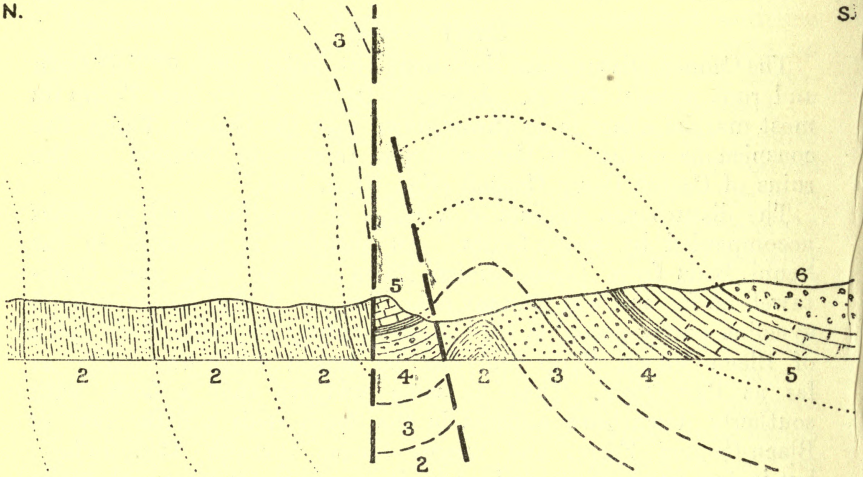
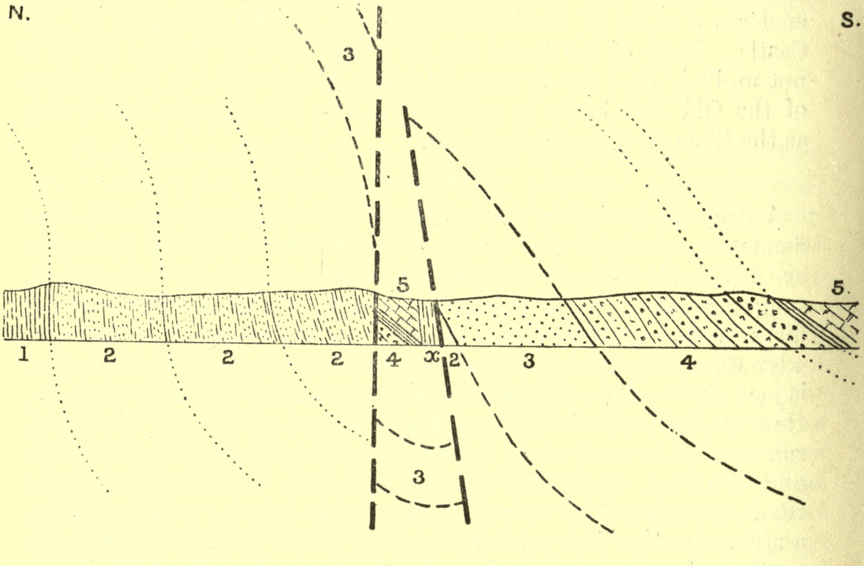
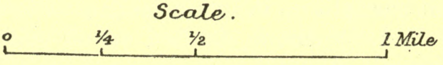


FIG. 11.—*Section across the Bryn-yr-odyn Disturbance.*

BY H. H. THOMAS.





6. Millstone Grit.
5. Carboniferous Limestone.

4. Brownstones.
3. Senni Beds.
2. Red Marls.

1. Silurian.
x. Broken strata.

shown in the stream which flows westwards from the Maes-y-bont road. After crossing the main road to Gors-lâs, near where the faults presumably run together, the disturbance is hidden by drift. But its probable course lies to the north of the hill on which Garnllwyd Farm stands and on in a west-south-westerly direction towards Porth-yr-rhyd, where a belt of smashed Old Red Sandstone is seen in the River Gwendraeth-fâch, below Llwyn Henry opposite the mill (Felin-fâch).

The disturbance thence ranges down the valley of the Gwendraeth-fâch, which in all probability owes its direction to the ease with which the disturbed strata along the line of crush could be eroded.

The Towy Valley.

The Llandilo Anticline.—The Llandilo Flags at Llandilo are folded into a well-marked anticline, the axis of which ranges about west-south-west under the alluvium south of the town. The core of the anticline is occupied by the *Didymograptus bifidus* Beds of the River Breinant. To the north of them the Ffairfâch Grit, with a general dip to the north-north-west, crops out to the south of the Pantau, and is succeeded northwards by the Llandilo Flags. South of the *D. bifidus* Beds the southern limb of the Ffairfâch Grit crops out with a south-south-easterly and southerly dip at Cwm-Cîb-canol, Ffairfâch and Glan-Cennen, and is followed on the south by the Llandilo Flags of the River Cîb. These are folded into a syncline—the Cwm Cîb Syncline—the axis of which ranges about west-south-west along the south side of the Cîb Valley.

Finally the Ffairfâch Grit is rolled up again along the south of the synclinal trough of Llandilo Flags at Maes-y-fallen, where it is inverted, and at Garn-wen also on the west side of the Cennen Valley.

The alluvium of the River Towy to the north of Golden Grove and south of Dryslwyn undoubtedly hides the crest of an anticline, which seems to have a slight easterly pitch, and causes older deposits to come to the surface towards the west. That it is not a simple anticline is more than probable, and from a study of the ground in the neighbourhood of Llanarthney it would seem that there were several folds accompanied by considerable faulting. Speaking of the Llandilo Flags Murchison remarks:—'Between Golden Grove and the ground occupied by these Flags on the opposite bank of the Towy is a distance of two miles occupied by a flat alluvial plain which has evidently been the scene of great dislocations and subsequent denudation.' His reasons, however, are not conclusive, as he had failed to recognise the existence of the anticlinal structure, not having realised that he had to deal with an ascending series on the northern side of the river.

It is probable that this anticlinal movement leaves the Vale of Towy at Llanarthney and affects the Arenig and Tremadoc rocks to the west and south-west of that village (p. 6), producing an anticlinorium with a slight easterly pitch. This anticlinorium is associated with several strike-faults of considerable magnitude which follow the direction of the axes of the folds (Fig. 1). It is noticed in this district that on the north side of the folded area the dip of the northern limb of the anticlines is fairly gentle while the southern limb is much steeper, and has a tendency to overfold in that direction. But in the case of the folds on the southern side of the anticlinorium the reverse holds good. The faults which accompany these folds produce effects such as would be produced by overthrusts; for instance, the fault at Ffinnant-uchaf (p. 14) suggests an overthrust from the north, as do the others to the north of Cwm-du; but those to the south between Cwm-du and the Silurian rocks seem to have resulted from a force acting from the south. In other words the Arenig and Tremadoc district of Llanarthney may be considered as a single anticline which has suffered considerable compression from both northerly and southerly directions.

The lenticle of Bala Limestone at Crûg in Sheet 212 (p. 31) marks the most easterly recognisable point of a disturbance which has a remarkable westerly range. From Crûg westwards the disturbance may be traced between Dynevor Park and the Carmarthen Road, where it throws Llandilo Flags on the south against Redhill Beds on the north. It continues to the neighbourhood of Birdshill, to the north of Cilsân, where it divides as at Crûg and encloses another lenticle of Bala Limestone (pp. 31, 32) between Redhill Beds and Llandilo Flags. Reuniting at the little River Myddyfi to the north of Glandwr Farm it continues to Aberglasney* and Grongar Hill as a single disturbance, having as before Llandilo Flags on the south and Redhill Beds on the north. On the eastern flank of Grongar Hill the disturbance is visible in a quarry and cart-road 200 yards north-east of Grongar East Farm, where the Llandilo Flags are converted into a crush-conglomerate, the rounded masses in which reach 7 or 8 inches in diameter. The disturbance continues over Grongar Hill on the northern side of the Camp, and enters Sheet 230 on the western side of the hill close to the ruins of Grongar West Farm, where the disturbed strata are clearly visible. Taking a more or less south-westerly course it passes to the south of Cwm Agal and Sarn Agal Farms (p. 35) and under the alluvium of the River Towy. It enters the solid ground again to the east of Dryslwyn Castle Hill, where it divides into three. One branch forms the northern boundary of the hill (Fig. 4, p. 29), and faults *Dicranograptus* Shales against Redhill Beds, while the other two separate the Llandilo Limestone, Bala Limestone, and *Dicranograptus* Shales from each other.

Part of the same disturbance probably forms the northern boundary of the Ty-pica ridge (p. 33) where inverted Bala Limestone is presumably faulted against Redhill Beds, and it is continued further west by the fault which cuts off the Bala Limestone near Llanegwad.

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* This disturbance was noticed, during the original survey of the district, in the neighbourhood of Aberglasney, and was indicated on *Horizontal Sections*, Sheet 3 (1844), Sect. 2.

This disturbance is therefore traceable for at least eight miles, and has Redhill Beds persistently on its northern side; it is, in fact, an overthrust fault, along which the newer Redhill Beds have been pushed from the north over the Bala Limestone and *Dicranograptus* Shales on to the Llandilo Flags, except in such places as Crûg and Birdshill where the Bala Limestone exists as lenticles lying on the fault-plane.

The Silurian-Ordovician Junction.

East of Llandilo there is evidence that much folding of the Ordovician rocks had taken place before the Silurian rocks were deposited; for the lowest Silurian beds are in contact with the *Didymograptus bifidus* Beds at Llwyn-bedw, with the Ffairfâch Grit at Maes-y-fallen, and with the Llandilo Flags in the Cennen Valley, west of which they lie against the Ffairfâch Grit again at Garn-wen Farm. This is due to complicated folding in the Ordovician, which does not exist in the Silurian rocks. An unconformity has been proved in the Llangadock district; and from the fact that Ordovician strata higher than any seen along the Silurian base crop out north of the Towy, we may infer that there is an unconformity here also.

The lower limit of the Silurian is certainly a fault in the region we are describing, and the structure could conceivably be accounted for on the theory of a fault alone; but in view of the facts detailed above, it is far more readily explained on the theory of an unconformity also.

Further westwards also the lower limit of the Silurian rocks is certainly a fault, hading at a small angle with the vertical (p. 41) and keeping a direction exactly parallel to the strike of the Silurian rocks. The actual junction is exposed in several stream-sections to the south of Golden Grove (p. 44), and in all cases it shows signs of considerable crushing. A stream which follows the strike for 200 yards runs in the actual fault. Though there is great discordance between the strata on its north and south sides, it is not necessarily a large fault, for, as we have seen, there is great probability that the Ordovician rocks were much disturbed before the Silurian were laid down upon them. But the evidence goes to show that there has been a certain amount of movement along this line, probably cutting out part of the Silurian rocks and also part of the Ordovician against which they rest.

Two faults, one to the east and another to the west of Carbury Mount (pp. 17 and 22), enclose a mass of Llandilo Flags and Ffairfâch Grit. They do not pass into the Silurian rocks, and must either be branches of the fault which exists at the base of the Silurian, or be faults belonging to an earlier system.

CHAPTER XII.

SUPERFICIAL GEOLOGY.

GLACIAL DEPOSITS.

Introduction.

The movement of the ice in the region embraced by Sheet 230 varied from nearly westwards to southwards according to the local configuration of the ground. That a great flow descended the valley of the Towy in a westerly direction is proved by the distribution of the drift and by occasional striated rock-surfaces, but it is easy to ascertain that the great scarp which forms the southern side of the valley failed wholly to confine the ice-flow, for not only did the ice take advantage of every gap in the hills to escape southwards, but it even crossed the scarp where it rises to a height of 900 feet or more. Over the remainder of the region the southerly direction prevails, inclining even a little to the east of south in places.

In the country lying further to the east (Sheets 231, 232) we found reason to attribute the southward movements of the ice in great measure to the Brecknock Beacons, but the ground now under consideration lies west of the western termination of that great upland. It is most significant, therefore, that notwithstanding that fact the southward flow is no less pronounced, for not only did the Tawe and Loughor Valleys give passage to great flows of ice, but even so big a range as the Silurian and Old Red Sandstone outcrops sufficed only partially to deflect it from a southward course. While it is impossible to enter fully in this volume into speculations on the causes of these movements, we may briefly point out that there is no ground on the north side of the Towy high enough and near enough to have pressed the ice across the scarp, and that we are driven to conclude that the overflow was due to a development of ice in Central Wales on a sufficient scale to give the upper layers a southward gradient over the lower parts of the scarp. These considerations suggest that it would not be wise to assume that the Brecknock Beacons solely determined the ice-movement over Monmouthshire and Glamorganshire. They may have played a part comparable to that of the Pennant scarp of Carn Mosyn* and acted merely as a local obstacle to the general south-west march of an ice-sheet.

One other fact in connection with the southward movement of the ice over obstacles ranging east and west remains to be noticed. In every case it was the upper layers only that surmounted the obstacle. Thus the lower part of the ice-sheet was following the

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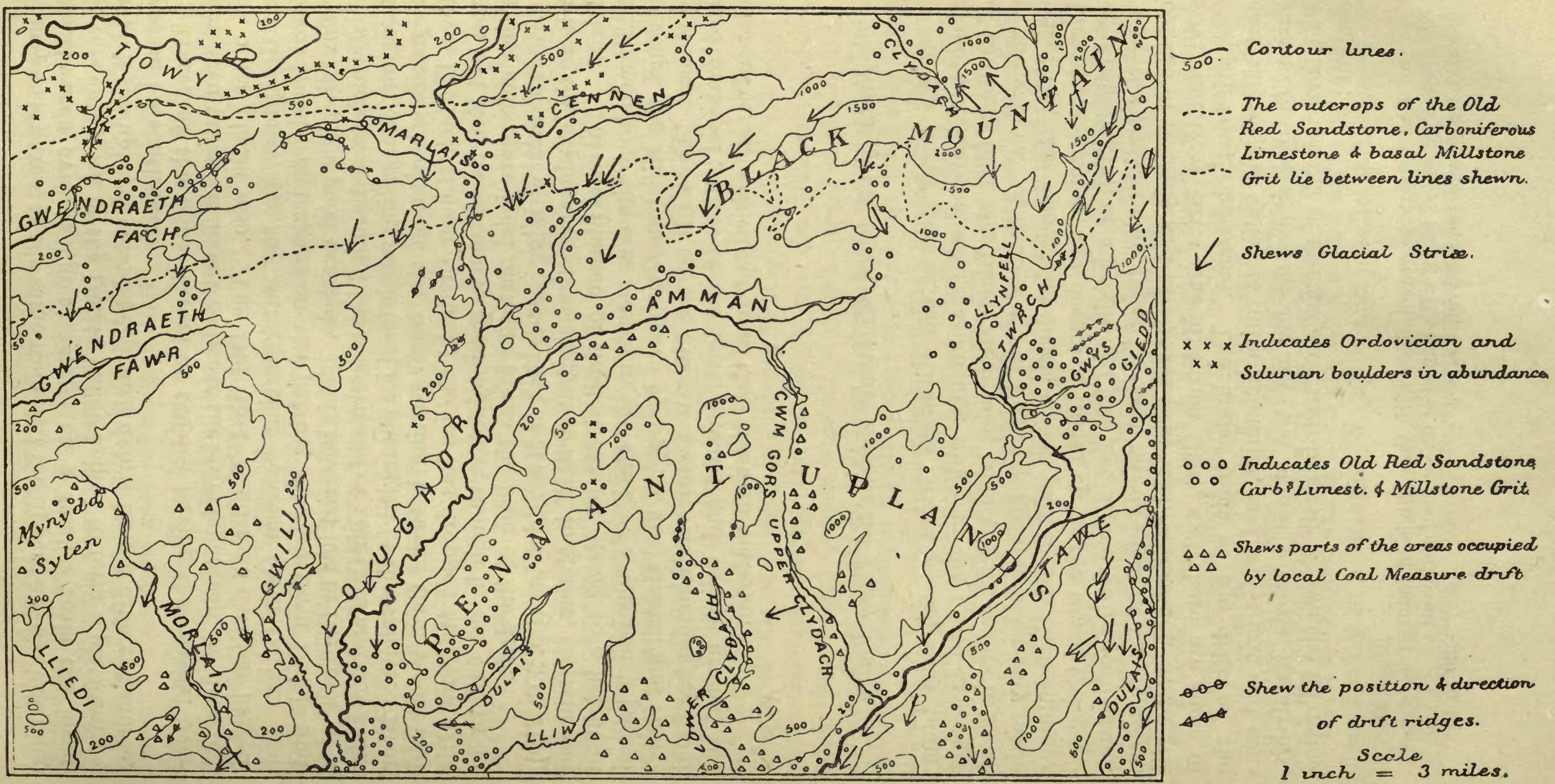
* A. Strahan in 'The Country around Merthyr Tydfil,' 1904, p. 99, *Mem. Geol. Surv.*

FIG. 12.—*Map illustrating the Glaciation.*


TOWY
CENNEN
MARLAIS
GWENDRAETH FACH
GWENDRAETH FAWR
BLACK MOUNTAIN
CLYDACH
AMMAN
LLYNFELL
TWRCH
GWYS
GIEDD
LOUGHOR
GWILI
MORLAIS
LLIEDI
Mynydd Sylen
PENNANT UPLAND
CWM GORS
UPPER CLYDACH
LOWER CLYDACH
DULAIS
LLIW
STAWE
200
500
1000
1500
2000
500 Contour lines.
The outcrops of the Old Red Sandstone, Carboniferous Limestone & basal Millstone Grit lie between lines shewn.
Shews Glacial Striæ.
× × × Indicates Ordovician and Silurian boulders in abundance.
○ ○ ○ Indicates Old Red Sandstone, Carb. Limest. & Millstone Grit.
△ △ △ Shews parts of the areas occupied by local Coal Measure drift
Shew the position & direction of drift ridges.
Scale 1 inch = 3 miles.

Towy westwards, at the same time that the upper part was escaping southwards over the great scarp; on a smaller scale the lower layers entangled in the Dulais Valley helped to form a platform on which the upper layers, loaded with débris from a different source, passed on southwards.

Traces of the upper layers of the ice having thus passed over and even taken a different course to the lower layers can be detected in other places also. The Old Red Sandstone detritus lodged on Graig-fawr, on the water-parting between Cwm Cathan and Cwm Dulais, and again on the parting between Cwm Dulais and Afon Lliw, is a good example. This material lies in the track of a flow which passed around the western end of Tair Carn and down the Loughor, over-riding much local ice entangled in the valleys. Near Bryn-chwyth also, on the water-parting between Cwm-y-gors and Cwm Clydach (Lower Clydach) the ice has dropped Millstone Grit and Old Red Sandstone in predominance, though in the valleys on either side more local material forms the bulk of the drift.

But the most striking case is that of Mynydd Sylen (pp. 207, 210), where the explanation first suggested itself to Messrs. Cantrill and Dixon. There a plateau of limited extent, rising to a height of 932 feet above the sea, stands in the track of a flow which passed through the Millstone Grit scarp by way of Foel Gastell and Banc-y-Mansel. The drift on the plateau contains an abundance of Old Red material; that of the lower ground and valleys around the plateau consists chiefly of local Coal Measure material.

A. S.

North of the Black Mountain, and in the Towy Valley.

On the north side of the Millstone Grit, Carboniferous Limestone and Brownstone escarpments, which in the north-east part of the map form the Black Mountain, boulder-clay occurs in most of the valleys. A little north of Pen-rhiw-gôch, boulder-clay made up of Old Red Sandstone débris covers part of the Carboniferous Limestone outcrop, and occurs in traces up to the top of Careg-yr-ogof (Sheet 212), at a height of 1,924 feet above Ordnance Datum.

In the boulder-clay lying in Cwm Sawdde-fechan the boulders consist of red grit and sandstone (Old Red Sandstone), white grit (Old Red Grey Grits and Millstone Grit), and there are some of Carboniferous Limestone. The upper limit of the drift on the east side of the valley is quite indefinite, and white grit and conglomerate blocks extend far up the slopes towards Esgair-hîr. The eastern bank of the river at Bryn-byrwallt shows the following section:—

	Ft.
Old Red Sandstone gravel, fine, with thin bands of loam -	6
Brown stratified loam, with seams of fine gravel and sand -	6
Old Red Sandstone gravel, coarser - - - - -	30 to 40

Blocks of coral limestone may be found in a small stream a little east of Llwyn-y-wennol, showing that there was a movement of ice northwards down the Sawdde-fechan valley.

Red boulder-clay extends up Fforch-Ceulan to the 1,500 feet contour; it contains grey pebbly-grit boulders, and striated stones are abundant. A little farther south the outcrop of the Grey Grits shows traces of striation in a direction N.W. and N. 40° W. at a height of 1,750 feet above the sea.

In the Clydach Valley the boulder-clay as exposed along the river consists chiefly of red sandstone boulders with some of white grit, Carboniferous Limestone and chert, but a more gravelly material has been dug by the side of the Llangadock road at Pen-cae-garw Farm, while still lower down the valley, at Carnau-gwynion, there is a large mound of brown sandy gravel as shown on the map.

Gravelly and sandy drift comes on at Glan-Toddeb; it consists of Old Red pebbles, among which are a few of pebbly white grit, possibly derived from the Old Red Grey Grits or the Millstone Grit; loamy gravel is exposed at Glan-Toddeb and fine brown loam without pebbles has been dug at Ty'r-cwm hard by.

On the escarpment to the south striæ on the outcrop of the Grey Grits half-a-mile south-east of Pont-Clydach point towards N. 35°–40° W., showing that the lower layers of the ice flowed down the Clydach Valley; but there is little doubt that the higher layers moved southwards through the pass of Pen-rhiw-wen (p. 197).

West of this pass there is evidence that some of the ice moved south-westwards along and obliquely up the limestone-escarpment; for at Carn Cennen a patch of drift exposed in the Cennen and composed chiefly of Millstone Grit material contains boulders of Old Red Sandstone which crops out at a lower level and some distance to the north; moreover, scattered among the Millstone Grit débris at Llyn-Du are numerous boulders of Old Red pebbly grit from the plateau-beds which must have travelled at least 2½ miles along the face of the escarpment from some point east of the Clydach, for to the west of that river this particular rock does not crop out.

These persistent attempts of the ice to escape southwards where-ever the escarpment of the Black Mountain would allow can be explained only as due to the influence of a thick body of ice piled up over Central Wales. There is no range of hills in the country immediately to the north of sufficient height to have acted as a centre of dispersion. Trichrûg, north-west of Gwynfe (Sheet 212), a mile north of the edge of the map, reaches a height of only 1,361 feet, a figure exceeded by several hundred feet by all the passes of the Black Mountain, and is itself glaciated nearly up to its summit by ice flowing in a direction W. 30° S. and parallel to the trend of the hill itself.

North of Llyn-Du the ice was subject to the guiding influence of the Cennen Valley. The boulder-clay adjacent to the river is made up chiefly of Old Red Sandstone materials, but it received a large accession of Silurian and Ordovician debris carried south-westward from the Towy Valley by way of the Camnant onto the outcrop of the Old Red Marls.

A section in the Camnant north-west of Ty'r-doppa exposes to a depth of 20 feet, boulder-clay, made up of red and green sandstone and marl pebbles with some Silurian and Ordovician grey and brown sandstones. This Silurian and Ordovician material does not reach the Cennen River for some miles farther westwards, the Cennen Valley ice holding its own, so that near Castell Careg Cennen the boulder-clay consists exclusively of Old Red Sandstone débris, as may be seen at the mouth of Cwm-ffinnant, three-quarters of a mile east of Trapp. Thence along the river to beyond Trapp the same character of drift prevails, but west of that place Silurian and Ordovician débris appears in abundance and extends up the south side of the valley towards the Carboniferous Limestone escarpment.

This evidence of the Towy Valley ice having invaded the Cennen Valley along the Camnant is supported by the striation on the hard Silurian grits. The bold ridge formed by these vertical strata is striated obliquely across in a direction S. 52° W. near Cilmaen-llwyd Quarry, curving to S. 40° W. to the north of Trapp, S. 30° W. near the Unitarian Chapel (three-quarters of a mile north-west of Trapp), and S. 26° W. and S. 20° W. to the north of Cefn-cethin, as the ice came within the influence of the gap near Derwydd Road Station. Through this gap the Towy ice pressed southwards; the boulder-clay in the Cîb Valley though it contains some few small boulders of Old Red Sandstone (derived possibly from the pre-Glacial alluvium of the Sawdde which joins the Towy at Llangadock) is essentially composed of Ordovician débris, as may be seen in a section on the north bank of the Cîb 360 yards west of Cwm-canol Farm. In the Cennen Valley itself, half-a-mile south of Ffairfâch, an elongated mound of sand and gravel is opened up in a small pit west of Maerdy Farm. The pit shows 8 feet of brown loamy sand, the upper two feet coarser and pebbly, with a sharp line between. The pebbles are of Llandilo Flag debris and vein-quartz, there being an entire absence of Old Red Sandstone. In a limestone-quarry by the side of the Cennen at the north-west end of this mound the dip of the beds is south at 50°, but the edges of the beds are turned up into and beyond the vertical position so as to dip north, an effect attributable to the drag of a mass of southward-moving ice.

Farther south a section in the Marlais River 350 yards south-west of Derwydd shows the Senni Beds striated in a S. 16° W. direction under 8 feet of bright-red boulder-clay full of well-striated pieces of Old Red Marls with a few of Ordovician and Silurian grits. The ice must have been moving directly up the steep scarp of the Old Red Sandstone and Carboniferous Limestone, and the striæ have the same direction as those on the Millstone Grit north of Piodau-fawr near Llandybie (p. 200). T. C. C.

On the north side of the Towy Valley boulder-clay occupies a large area lying to the north of Dryslwyn Castle and north-west of Grongar Hill, but slightly elevated above the alluvium; much of it has probably been levelled and redistributed by river-action. It may be described as a yellow pasty clay with a paucity of boulders, such as are seen consisting largely of grits and conglomerates which are unlike any rocks met with in the area surveyed, but which occur in place to the north and north-east. There appears to be a complete absence of recognisable local material.

In a smaller patch of drift to the north of Cincoed at the extreme north-western corner of the map a small dingle shows some thirty feet of gravelly boulder-clay which to the north passes into gravel of a moundy character.

On the south side of the valley a large mass of boulder-clay overspreads the low-lying shale-country between Golden Grove and the Towy alluvium. It has been cut into by the stream to the north of Golden Grove Bridge to a depth of 14 feet and near the north lodge of Golden Grove it is seen to a depth of some 5 feet. It presents the same characters as that on the north side of the Towy Valley with a general absence of local Silurian and Old Red material, and a preponderance of grits, sandstones and conglomerates probably having a northerly origin. The same drift sweeps round the north side of Carbury Mount where it is seen to a depth of 12 feet, and round the western end of the hill and into a hollow south of it. Thence westwards for more than a mile it has been banked up against the Silurian slopes of Berach and Lan and at the same time forms a low-angled cliff overlooking the Towy alluvium.

At Heol-fawr south of Llanarthney the drift consists of a gravelly boulder-clay which passes into, or more probably under, deposits of fine sand and gravel presumably of glacial origin. Material of this description is well exposed in the road-cutting opposite Heol-fawr Mill, where it may be noticed that it differs from the alluvial deposits of the main valley in containing no fragments of Old Red Sandstone. It has, therefore, come from a different source, and probably from one remote from the area of deposition. These gravels flank both sides of the narrow valley of the Gwynon which flows from Middleton Hall to Llanarthney, and pass over the *col* in which the Middleton Park ponds are situated, towards the east-and-west valley of the Gwendraeth-fâch. They are well seen in Middleton Park to the east of the large artificial lake known as Pond-ddu. That this line of gravels marks a direction of overflow for the ice and the later glacial drainage seems probable, especially as the gravels are formed not from the rocks on which they lie, but from those which crop out to the north of the *col*.

A large patch of drift east and north of Glascoed-isaf, and several smaller patches to the west of Llanarthney, present the usual characters of the drift of the Towy Valley, namely that of a stiff yellow clay with boulders of grit and conglomerate. To the west of

Llanarthney near Bremenda-uchaf a mass of moundy gravel is surrounded by terrace-like accumulations of fluviatile character.

The moundy gravels rise a little more than 50 feet above the level of the Towy alluvium. They are well exposed in the deepest railway-cutting a little to the west of Barley Mount two-thirds of a mile west of Llanarthney. The section, though much overgrown, shows a fine sandy gravel with many rounded shale-fragments. Northwards this mass, where it abuts on the Towy opposite Llanegwad, forms a cliff consisting of a gravelly boulder-clay with boulders of far-travelled rocks.

The gravels of Middleton Park give place southward, on the Old Red Sandstone country, to boulder-clay and tills of almost purely local character. The drift passes over the *col*, marked by a peat-bog to the south of Middleton Hall, and flanks both sides of a shallow valley which leads into the valley of the Gwendraeth-fâch. To the west of Lan it is exposed to view to a depth of 6 feet. The prevailing tint is red, the deposit being largely made up of Old Red Sandstone material with a few far-derived boulders of grits and conglomerates. Locally it becomes gravelly, but is never sufficiently free from clay to be classed as a gravel. Here again the prevalence of Old Red Sandstone detritus to the south of its outcrop and its absence to the north proves that the ice passed southwards through the valley.

The direction of ice-flow in the Towy Valley was undoubtedly in part a deflection of that of the main ice-mass, due, in all probability, to the depth of the valley and the steepness of its southern side. That the ice worked down the direction of the main valley is suggested by the contours of the slopes and the bevelling of hard rocks on the southern side, while it is more or less definitely proved by the striæ observed by Mr. Codrington* under glacial material during the erection of Dryslwyn Bridge. Here, on a rock-surface ranging from near water-level to 8 feet below Ordnance Datum, the striæ ran nearly east and west.

H. H. T.

The North Crop east of the Loughor.

The Giedd in the lower two miles of its course traverses an undulating plain, spread thickly over with boulder-clay which is generally packed with large stones. The plain slopes gently southwards as a whole, but its surface is diversified by numerous low rounded ridges with their longer axes pointing W. 35°–40° S., separated by a corresponding number of swampy hollows. Two miles north of Cwm-Giedd village the boulder-clay is red and composed almost wholly of Old Red Sandstone, Carboniferous Limestone, and Millstone Grit; one mile further south Carboniferous shale predominates in the matrix, and the mass takes a blue tinge; but it still contains an abundance of limestone. The surface of the plain is dotted over with large blocks, nearly all attributable to the Millstone Grit. Occasionally these boulders have been piled up in ridges or dropped in lines more or less in the direction of glaciation, but there is no such conspicuous example of a train of boulders, as that known as the Saith-maen* (Sheet 231).

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* *Quart. Journ. Geol. Soc.*, vol. lviii, 1902, p. 35.

The same remarks apply to the lower reaches of the Gwys, but it will be noticed that this river for the last two miles of its course flows in the direction of glaciation, not improbably having been driven to this course by the drift-ridges mentioned above.

A. S.

Boulder-clay largely covered with peat occupies the wider part of the Twrch Valley at the mouth of the Twrch-fechan, and is exposed in several sections on the left bank of the main stream. It consists almost exclusively of sandstone and shale-débris derived from the Old Red Sandstone slopes to the north; but south of the base of the Carboniferous Limestone it contains in addition some material derived from the Grey Grits and the Lower Limestone Shales.

Where the river passes onto the Millstone Grit, however, that rock rapidly replaces the Old Red Sandstone in the drift, and so completely that it is difficult to distinguish glacial material from disintegrated rock. The inference that the drift was deposited by ice flowing southwards down the Twrch Valley is confirmed by the evidence of the striæ. The grit-crags on the western edge of Esgair-hîr are striated in a direction S. 18° E. at a height of about 1,930 feet above Ordnance Datum; and east of Blaen Llynfell in a direction S. 3° E. and S. 12° E. In the Twrch Valley itself striæ on the grit close to the water's edge one-third of a mile below the mouth of the Twrch-fechan point directly down the river. The bare surfaces of the grit of Tyle-garw exhibit a large number of striated patches together with *roches moutonnées* and bevelled crags, the direction of glaciation gradually changing from S. 12° W. at the northern, to S. 25° W. at the southern end; while east of Bwlch-y-ddauwynt the striæ are equally clear and abundant, and show a like tendency to swing more and more towards the west.

At numerous points on the moorlands between the Gwys-fawr and the Twrch, blocks of Old Red Sandstone and fragments of Carboniferous Limestone chert may be found on the surface or embedded in the boulder-clay which borders the streams; and boulders from the basal Millstone Grit are abundantly strewn over the outcrop of the shales of the middle subdivision.

At Dorwen, where a small but well-marked drumlin rises on the west side of the river, the boulder-clay spreads out over the more open ground, extending westwards over the wide strike-valley marking the outcrop of the Lower Coal Series, and northward in narrow strips along the upper reaches of the Llynfell and Amman rivers; it consists chiefly of Millstone Grit materials.

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* T. C. Cantrill in 'The Country around Merthyr Tydfil,' 1904, p. 110, *Mem. Geol. Surv.*

The grit-plateau of Cefn-y-Garn-Fadog is glaciated right across its summit, and a small striated and well-polished patch may be seen a few yards east of the Trigonometrical station, 1657; the ice moved up from the lower ground lying to the north and travelled in a direction S. 10°–15° W. Most of the crags are more or less bevelled. Between the Llynfell and the Amman-fawr the grit is striated in a direction varying from S. 2° E. to S. 25° W., and the outcrop of the Millstone Grit Shales is strewn with grit-boulders, among which are some of Old Red Sandstone.

T. C. C.

In a river-cliff of the Twrch, 900 yards north-east of Pen-y-wern, the following section was disclosed:—

	Ft.	In.
Stony clay with boulders of quartz-grit	5	0
Well-bedded sand, loam and grit - -	15	0
Blue boulder-clay, seen to - - -	30	0

The sand-bed is visible at intervals for a few yards, but does not appear elsewhere. No doubt it is lenticular, but the slipping of the drift more often than not hides such strata.

On the northern side of the railway, 500 yards south-east of Melin Palleg, there are striæ pointing W. 10° S. A few yards north of the mill the boulder-clay is full of Old Red, Carboniferous Limestone, and Millstone Grit blocks, but nearer to Cwm Llynfell the blocks are neither so abundant nor so large.

An esker of sand and gravel forms a conspicuous little hill between the Twrch and the Llynfell, and sand has been dug also close to Ty-gwyn. A pit in the esker shows in places 4 feet of coarse gravel on top, eating irregularly down into the sand, and contorted with the upper layers of the sand. It contains many boulders of pebbly Millstone Grit and may be regarded as a gravelly type of boulder-clay. The sand is fine, bedded and running, with bands of loam and much coal-dust. It includes some pockets of gravel, together with a few great blocks of Millstone Grit. Old Red occurs but sparingly and in small blocks; it is more abundant on the same latitude further east.

A. S.

North of the villages of Cwm Llynfell and Ystrad-Owen, on the low divide between the Twrch and the Amman valleys, the drift becomes gravelly and assumes the form of mounds enclosing peat-bogs. The gravel is exposed in several pits; the pebbles are partly rounded and consist of Carboniferous grits, sandstones and shales, together with coal, rottenstone and Old Red sandstone. The following details were recorded in a pit 150 yards north of the railway bridge west of Cwm Llynfell Platform :—

	Ft.	In.
Gravel—brown, the matrix consists of yellowish-brown sand; the pebbles (up to 6 in.) are subangular and subrounded, of Carboniferous grits (grey, brown, and yellow), dark shale and some Old Red sandstone. No definite bedding, but pockety	4 to 6	0
Sand—brown, loamy and very fine-grained, with pebbles (up to 1 ft.) in the lowest foot	3	6
Sand—coarser, dry, with coal-fragments		3
Sand—brown, loamy and very fine-grained	2	0
Sand—coarse, loose, with streaks of coal-fragments	6	0

This gravel soon gives place to boulder-clay, of which there is a good section in a cutting on the Gwaun-cae-gurwen Railway near its junction with the Midland Railway; the cutting shows 8 feet of brown coarse sandy clay with partly rounded boulders, up to 3 feet in length, of Carboniferous grits, and, less abundantly, of Old Red sandstone.

In the Garw Valley north of Brynamman the boulder-clay is in places over 50 feet thick, and has been derived chiefly from the Millstone Grit, but it contains many Old Red Sandstone boulders. One block, 5 feet 6 inches long, of pebbly red grit (Old Red plateau-beds) lies by the side of the Garw near its junction with Nant-caws and three quarters of a mile south-south-west of the pass of Pen-rhiw-wen. As the plateau-beds disappear some little distance to the east, the block must have been carried westwards along the northern face of the escarpment, and then southwards through the pass which is 1,618 feet above ordnance datum. The ice can have taken this route only as the result of the burying-up of the lower ground to the north of the escarpment by a great ice-sheet. Faint evidences of striation and bevelling are observable on the Millstone Grit a little south of the pass, and the striæ on Gareg Fraith point S. 20° W. Farther south the Farewell Rock just above a quarry on the northern side of Craig-derlwyn 100 yards north-west of the eleventh milestone from Llangadock is striated in a direction S. 20° E.

In Cwm Pedol, north of Garnant, the boulder-clay is made up chiefly of Millstone Grit débris; but at Pant-y-ffynnon Farm at an altitude of about 730 feet above ordnance datum, a conspicuous gravel-mound overlies the boulder-clay and presents the following section 50 yards west of the farm-buildings :—

	Ft.	In.
Turf and soil	3	0
Gravel, coarse, subangular; a light-brown sandy matrix full of angular and subangular pieces of light- and dark-grey grits and sandstones (Millstone Grit); a few ironstone-nodules, numerous fragments of shale; a few small pebbles of Old Red sandstone; coal-pebbles up to 1 in. in length. The pebbles range up to 1 ft. 3 in., but average 4 or 5 in. Base uneven.	3	0
Gravel, finer, of similar materials, seen for	3	0

Many of the pebbles in the talus at the foot of the section are striated. The Old Red Sandstone pebbles are mostly of the size of peas, and there are about 30 to the square yard of the face ot the section. The coal-fragments were derived presumably from some thin vein in the Millstone Grit, and the Old Red pebbles may have travelled by way of the north side of Foel-deg-ar-bedol.

The drift of the Amman Valley at Glanamman widens out northwards up the Berach Valley and southwards up Cwm Garenig. It consists chiefly of Coal Measure material with a smaller proportion of Millstone Grit and Old Red Sandstone. Locally the latter becomes abnormally abundant; thus at Llwyn-du, half-a-mile north-west of Glanamman Station it forms the bulk of the drift, having come probably from the Cennen Valley round the north-west face of the great ridge of Tair Carn. That the ice extended far up the north-western face of this ridge is evident from the excellent examples of striation and bevelling on the grit along Gwythwch Brook, where the striæ point S. 35° to 60 ° W., but plainly swing southwards round the south-west end of Tair Carn. Two small pieces of Old Red Sandstone were observed among the Millstone Grit débris at a quarter of a mile north-east of, and only a few feet below, the highest point of Tair-Carn Uchaf.

In the Amman Valley the northern bank of the river a little below Aber Garenig Farm shows some 27 feet of dark grey boulder-clay, weathered brown in the upper part.

South of the valley the upper layers of the ice evidently over-rode the high ground of Mynydd Bettws, for large blocks of Millstone Grit and Old Red Sandstone lie here and there on the moorlands; one in particular, of Old Red pebbly grit, known as Llêch-yr-halen, measures 7 by 6 by 3 feet, and stands at an altitude of about 1,110 feet a little north of the large peat-bog marked on the map. Boulders of like materials extend southwards into the valleys of the Lower Clydach and Cathan.

At Pontamman the Amman Valley drift runs continuously on into the Loughor Valley, and spreads over the ground enclosed between the two rivers near Ammanford. On the Amman above Pontamman the drift exposed along the north bank shows a tendency to become more gravelly; a section 200 yards above the bridge shows clean coarse gravel 12 feet, over grey loamy boulder-clay 20 feet, with a band 1 to 2 feet thick of grey loam at 6 feet from the foot of the section.

The Loughor Valley ice-flow included that which overflowed from the Cennen Valley and crossed the Millstone Grit scarp near Forge Llandyfan, near which place the drift contains much limestone and Old Red sandstone; the grit-ground east of Glyn-hîr is well bevelled and striated in directions varying from S. 14° W. to S. 30° W. There is much Old Red sandstone and limestone in the boulder-clay along the Loughor at Glyn-hîr and at Cathilas farther south; a conspicuous mound between Myddyn-fych and Ammanford appears to consist of reddish loamy gravel.

Farther south the drift extends far up the slopes of Mynydd Bettws; it consists chiefly of Coal Measure material with little

Millstone Grit and Old Red Sandstone; but in Nant-y-ffîn, at 150 yards south-west of Tir-Eleanor-Morgan, it is made up almost exclusively of small pieces of Old Red marl and micaceous red sandstone, together with a large number of mudstone and shale fragments, most of which are striated. Their lithological characters and the fact that they contain polyzoa and *Pentamerus oblongus* prove that these fragments were derived from the Silurian rocks, the nearest outcrop of which lies about 6 miles to the north.

Still farther south, the drift in Cwm Cadno contains much Old Red material, and is well-exposed in Cwm Cathan in a gully 200 yards east of Cwm-cathan-uchaf Farm, where it consists of red and green sandstone and cornstone boulders (Old Red Sandstone) ranging up to 3 feet in length; white grit, probably from the Millstone Grit, Coal Measure sandstone and shales, Carboniferous Limestone, and mudstones possibly from the Silurian outcrop. At 400 yards farther up the main valley a section on the south side of the stream exposes 20 feet of stiff brown boulder-clay full of small striated pieces of Pennant sandstone, Old Red marl and sandstone, white grit, and some of Carboniferous Limestone.

The drift in the broad valley which extends southwards from Derwydd Road through Llandybie to Ammanford takes the form of gravels, and was probably the work of effluents from the ice-sheet during a late period of its existence. The materials were derived chiefly from the Cennen Valley; and from the fact that they extend southwards it seems certain that the effluents took that direction and not the northward course now followed by the Cennen. This gravel is well-exposed at Derwydd Road Station, where it consists of well-rounded pebbles of Old Red marls, green sandstone, and a few which may be Silurian grits.

The village of Llandybie stands on the same gravelly drift, but there are few sections; the railway-cutting north of the station exposes a large rounded boulder of red marl, 8 feet by 6½ feet by 3 feet, and three large boulders of Millstone Grit. About a mile south of the village this type of drift gives place to boulder-clay which spreads westwards up Nant-Lash towards Pen-y-groes and southwards to Ty-croes, where it consists chiefly of Carboniferous grits and limestone, Old Red sandstone and marls, and some Silurian mudstone. On this area several outlying mounds of gravel occur, as for instance at Glyn-glâs and Glyn-tai; their axes lie generally in a south-south-west direction and conform with the direction of the ice-flow.

This direction agrees with that of the striæ on the Millstone Grit extending from Forge Llandyfan westwards through Llandybie. On Careg-y-Dwfan some striæ just below the summit (926 feet above Ordnance Datum) point S. 32° W., that is, obliquely across the scarp; though it is interesting to find that at the southern foot of the hill, where the slopes run more nearly west, the lower layers of the ice took that direction also. But along the grit-ridge towards Llandybie the striæ gradually swing round towards the south.

In the gap in the escarpment at Llandyfan some Silurian débris may be found in the drift, showing that the Cennen Valley ice availed itself of the opportunity of escaping southwards. West of this gap the striæ point S. 18° W. at Garn-bica-fâch, and a few hundred yards west they swing round to S. 15° E., the ice being deflected no doubt by a mass pressing southwards down the Llandybie Valley. West of this valley, however, they lose their easterly movement and on the grit-crops north of Piodau-fawr they resume their more normal direction of S. 16° to 25° W.

T. C. C.

The Pennant Uplands east of the Loughor.

A thick mass of boulder-clay overspreads the south-eastern side of the Tawe Valley above Ystradgynlais, adding not a little to the difficulty of locating the faults described on p. 95. The material is blue, but it contains abundant blocks of Old Red Sandstone and Carboniferous Limestone. A slope to the Four-feet Vein traversed boulder-clay and sand for a distance of 40 feet. Southwards this deposit extends with slight interruption down Nant-y-Rhôs, where also Old Red detritus abounds, and thus finds its way across to the Dulais Valley. The small part of that valley which lies within the map under description is occupied by a drift of the boulder-clay type, but one conspicuous mound near Llwyn Gruffydd shows nothing but pebble-gravel in its sides, and in some other places the soil is gravelly. Towards the centre of the valley, full in the path of the Brecknock ice-flow, Old Red material abounds together with great blocks derived from the adjacent hill-sides, but in more sheltered side-streams, such as that above Glyn-y-bedd, the far-travelled material becomes scarcer, as was the case in the Neath Valley.* The direction of the ice-flow was slightly west of south, and was determined no doubt by that of the valley and of the ridge of Mynydd March-Hywel. On Farteg Hill striæ at a height of 1,050 feet above the sea point S. 30° W., and at Blaen-nant-Meirig, S. 15° W.; in the latter place there lie close by some boulders of Old Red Sandstone at a height of about 950 feet. A group of striæ around Gelli-galed, at height of 750 to 950 feet above the sea, point a few degrees on either side of south, and some on the eastern side of the valley point S. 28° W. That the Dulais Valley was filled to overflowing is shown by an interesting striated rock-platform on the ridge of Mynydd March-Hywel. The platform lies at a height of more than 1,100 feet, in a shallow *col* in the ridge. The striæ, which may be observed over a large area by clearing the thin soil, range W. 30°–35° S. and therefore cross the ridge obliquely. Obviously they mark the escape of an arm of the ice from the Dulais westwards.

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* A. Strahan in 'The Country around Merthyr Tydfil,' 1904, pp. 99, 101, *Mem. Geol. Surv.*

In parts of the Hendre-Caradog Valley Old Red boulders become quite scarce, as in other similarly sheltered cwms, and the drift generally has a blue tinge. It attains a thickness of more than 30 feet and in one place contains a band of well-bedded stony clay and grit. The drift south of Cil-y-bebyll may be described as a stiff till, generally blue, but always with some old Red Sandstone detritus. It occasionally rises into a low ridge, or drumlin, with the longer axis pointing south ; some striæ, 920 yards south of Melin-y-rhos, point S. 10° E.

The Tawe Valley traverses the Pennant as a deep and narrow trench of remarkable straightness. On its sides there hang at intervals narrow strips of boulder-clay and gravel, of great apparent depth as viewed from below, but making little show upon the map. The material has a coarse aspect, the average size of the boulders being considerable, and Old Red Sandstone is abundant. Clearly we are here again in the track of a direct flow of the Brecknock ice.

The depth of the valley has never been ascertained, but there is reason to think that it extends nearly to sea-level. An attempt was made to sink shafts on the alluvial flat between the river and the railway 900 yards above Cwm Clic. A borehole passed through 20 feet of gravel and 110 feet of quicksand. Two pits also were sunk to a depth of 50 feet by means of tubbing, in similar ground, but no solid rock was reached in borehole or pits.* and the shafts were eventually sunk in the rocky side of the valley, above the alluvial flat: The borehole was 50 yards distant from the foot of the rock-slope, and the alluvial flat is about 150 feet above the sea. At Swansea the gravel was met in colliery-workings under this same valley at a depth of 150 feet below Ordnance Datum.† In the Neath Valley also, 6½ miles above Neath, sand was found to extend to a depth of 70 feet or nearly to the level of Ordnance Datum, and below that level nearer the estuary. The rock-floor in the Loughor Valley also descends below sea-level (p. 204). In all these cases it is impossible to distinguish the glacial sands and gravels from the superficial alluvial layers.

Above and below Pontardawe the drift becomes gravelly, as often happens along a main valley. Its moundy character and the fact that it runs up the hill-side in places distinguishes it from river-terraces. It merges, moreover, into boulder-clay. Some striæ in the railway 850 yards south of Pontardawe Station, and again close to Ynys-y-mond-uchaf, point straight down the valley.

A. S.

That the ice surmounted the Pennant scarp south of Gwaun-cae-gurwen is proved by the occurrence of boulders of Old Red Sandstone and Millstone Grit up to the highest point, 1,155 feet above Ordnance Datum. At Pen-how, at 1,000 feet, pebbly white grit (Millstone Grit) boulders, ranging up to 6 feet long, have been left stranded on the hill-side; while at the top of the Egel Valley, between Bryn-melyn and Pen-rhiw-fawr, there lies a block of red quartz-conglomerate (Old Red plateau-beds), 3 feet 9 inches long, on the surface. The boulder-clay bordering the Egel itself contains boulders of Carboniferous Limestone up to 2 feet 9 inches, and many of Old Red Sandstone. At Fforch-egel Farm the river cuts into grey till 20 to 30 feet thick, with boulders, many of which are striated, of Coal Measure sandstones, shales, and ironstones, and some of Millstone Grit and Old Red Sandstone. In the stream west of Fforch-egel Carboniferous Limestone and chert and Old Red Sandstone and Millstone Grit boulders are not infrequent. The nearest point from which such an assemblage could have been derived is some eight miles to the north-north-east; and the comparative rarity of such materials in the low ground about Cwm Llynfell (p. 196) suggests that the upper layers of the ice travelled more directly south-westwards and crossed the local ice-flow.

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* For this information I am indebted to Mr. E. H. Hedley.

† 'The Country around Swansea,' 1907, p. 135, *Mem. Geol. Surv.*

T. C. C.

At Pen-twyn a dark-coloured till is chiefly composed of Coal Measure material, while Old Red boulders are scarce. The same remark applies to the lower mile of this valley, except that in a tributary at Gelli-Lleucu-fâch, in blue till exposed to a thickness of 20 feet, nothing but Coal Measure rocks could be found.

A. S.

In the upper part of Cwm-y-gors the boulder-clay consists chiefly of Coal Measure materials with a number of Old Red and Millstone Grit boulders to indicate its northerly origin. In Nant-Rickett a 9-foot block of Old Red pebbly grit lies on the slopes at the old coal-workings, and a few large blocks of Old Red Sandstone and Millstone Grit are to be found scattered over the moorland farther west, as at Banc-cwm-Helen, in the valley east of Hen-rhyd, and farther south on Bryn-mawr (1,133 feet above Ordnance Datum), and similar boulders extend down the upper part of Cwm Clydach.

T. C. C.

In the lower part also of Cwm-y-gors Old Red material is scarce, but pebbly grit, either of Millstone Grit or Coal Measure derivation, is fairly abundant. Near Gelli-gron Mill there are more than 80 feet of boulder-clay with many great blocks of Pennant.

Here again we get remarkable proof of the overflowing of the ice from one valley to another. Carn-llecharth and Mynydd Gellionen form a continuous ridge separating the Upper Clydach (Cwm-y-gors) from the Lower Clydach (Cwm Clydach). In a depression on the ridge, but right on the water-parting, there are striæ ranging across it in a direction W. 20° S., at a height of 910 feet above the sea. The tendency to escape westwards from an overflowing valley is to be noticed here as in the case described on p. 200.

Parts of the Lower Clydach Valley (Cwm Clydach) have been thickly clogged with boulder-clay. At Llechws, 1,200 yards north-west of Llwyn-Ifan, there is a well-shaped drumlin and the stream below discloses a gravelly boulder-clay with some blocks of Old Red Sandstone, and a profusion of Millstone Grit. North of Bryn Chwyth on the hill to the east, and at heights of more than 900 feet above the sea, there lies a sprinkling of drift in which boulders from those formations so far predominate as to show that the ice which overrode Carn-llecharth had a more distant source than the lower layers in the valleys. Old Red detritus is fairly abundant also in the drift north-west of Ty'r-waun on the western side of the valley.

Three hundred yards below Cwm Clydach Factory the stream pushes an elbow under a cliff of about 120 feet of boulder-clay in which there are interbedded about 20 feet of sand and pebble-gravel, comparable with the band described on p. 196. At intervals down the stream gravel has been disclosed in the banks by the washing away of boulder-clay from above it, and in places what we have called boulder-clay might equally well be classed as gravel, especially near its lower margin. In the Tawe Valley it merges into gravel.

A broad and monotonous expanse of boulder-clay overspreads the head of Afon Llan. An occasional Old Red Sandstone boulder on Mynydd-y-Gwair at heights of over 900 feet prepares us to find this rock in Afon Llan also, but it is not so abundant as pebbly grit. South of Cynghordy the clayey type of drift merges into the gravelly type and we get mounds and banks of coarse pebble-gravel, with many great boulders of pebbly grit and some of Old Red Sandstone.

In Afon Lliw the most noticeable feature in an indefinite mass of clayey and gravelly drift below Felindre is the abundance of boulders of Millstone Grit and Old Red Sandstone. The route they followed is not obvious. If they came over the mountain from the north-east and along the Lliw they should have left traces, but both the upper part of the Lliw and Cwm-Nant-ddu, as well as the mountainland between them, are free from drift. More probably they travelled southwards by the way of the Dulais and overflowed thence southwards and eastwards. This route is suggested by the fact that similar boulders abound on Bryn-bâch Common and on the edge of the steep southern side of Cwm Dulais.

In the narrow and steep-sided ravine of Cwm Dulais (Loughor Valley) there is room for no more than a strip of boulder-clay, which however is upwards of 50 feet thick in places. When the ravine opens out into the Loughor Valley the boulder-clay merges into gravels which climb irregularly up the lower end of Cefn Drum, and near their margin there lies a remarkably well-glaciated boulder of quartz-grit, 6 feet in length. Old Red boulders occur all up the valley in considerable abundance, but the boulder-clay is blue and composed chiefly of Coal Measure detritus, therein differing from the gravel of Bryn-bâch referred to above.

About three miles up Cwm Dulais a *col*, 840 feet above the sea, leads northwards into Cwm Cathan. In this *col* lies a mass of coarse gravelly boulder-clay full of Millstone Grit and Old Red Sandstone, a typical 'Brecknock drift.' Here, therefore, is a likely explanation of the composition of the drift of the Lliw. The general trend of the ice was nearly south. That it passed from Cwm Cathan to Cwm Dulais is proved; Cwm Dulais was almost in its line of travel, and led it to Bryn-bâch, where again it has left conspicuous traces of its passage over the water-parting. Thence it was downhill into the Lliw.

On the brow of Bryn-bâch Common above Cwm Dulais there are striæ on rock that appears to be in place. They point nearly due west, down the Dulais, and not across the Common towards the Lliw. This fact, taken with the difference between the drifts of the bottom of Cwm Dulais and of Bryn-bâch Common, indicates that the upper layers only of the ice flowed southwards, while the lower layers were drawn westwards by the depth of the valley.

Camffrwd brook drains a deep hollow between the Pennant hills of Graig-fawr and Cefn Drum. Boulder-clay is exposed in its banks to a thickness of upwards of 20 feet in several places, and spreads up the slopes at the head of the valley to a height of more than 800 feet above the sea. The reddish tinge and the abundance of Old Red Sandstone material attract attention, both in the bottom and on the sides of the valley; obviously the valley was invaded by the far-travelled ice from the north, and on seeking for the route followed by this flow we find that Graig-fawr is dotted with boulders of Millstone Grit and Old Red Sandstone right over its crest, 900 feet above the sea, and that boulders of the former, up to 7 feet in length, are scattered over much of Cefn Drum also. Two general inferences may be drawn from these observations; firstly, that the Loughor Valley gave passage to an ice-stream from the north across the coal-field and, secondly, that the ice surmounted all heights up to at least 900 feet above the sea, and therefore spread considerably beyond what would be strictly described as the margins of the valley.

Pebble-gravel is the prevailing type of drift in the Loughor Valley around Pontardulais. Occasionally it rises into low mounds or ridges, but much of it is so nearly flat as scarcely to be separable from the recent alluvial gravel of the Loughor and the Dulais. Two wells have been sunk on the north side of the Dulais; one, 350 yards east of Pontardulais Bridge, failed to reach the bottom of the gravel at 57 feet; the other, 830 yards east of the bridge, failed to bottom it at 45 feet. In the former case the bottom of the well is about 17 feet below Ordnance Datum; in the latter about 10 feet above that datum. A third well on the east side of the railway, 450 yards north of the station, did not reach the rock at 23 feet depth. All three wells started on the alluvial flat, but part of the gravel is likely to be glacial, the surface only having been re-sorted by the existing rivers. The lower part of the Loughor valley, like those of the Tawe and Neath (p. 201), would, in the absence of superficial deposits, be occupied by an arm of the sea.

Boulders of Old Red Sandstone and Millstone Grit abound in the gravel, and this fact, together with the arrangement of the mounds, points to the direction of transport having been down the valley and nearly due south. Some striæ in the side of the railway, 740 yards N.E. of Tal-y-fan, point S. 3° E.

Towards the southern margin of the map the gravel-features become more conspicuous, and one ridge especially is noteworthy. It commences a few yards west of the Birch Rock Colliery-siding on the L. & N.W. Railway, runs southwards under Pentre-prys-cedwyn, curves round before reaching Waun-gron, and trends north again past Castell-du. For all of this distance it presents a steep convex front to the south, while on the north it encloses in its concavity a water-logged tract of alluvium, liable to be covered by the highest tides. Other gravel-mounds rise as islands from the alluvium, while elsewhere alluvial deposits fill hollows in the gravel, as a result of obstructed drainage. These remarks apply to all that part of the valley lying south of Llanedy, and in general terms it may be said of such a region that the effects of post-glacial denudation are manifested as much in the levelling-up of the hollows as in the levelling-down of the eminences in the surface of the glacial deposits.

A. S.

The North Crop west of the Loughor.

Two small patches of drift occur on the north side of the upper part of the Marlais Valley, and another wanders through several Old Red Sandstone valleys from the main road westwards to Gilfach and southwards to the Inn (Temple Bar), where two arms spread out one to the east and the other to the west. The two first-mentioned patches consist of a yellow and red clay containing a large proportion of Old Red Sandstone, on which they lie, but also holding a fair quantity of Silurian material as well as grits similar to those which occur as boulders in the Towy Valley (p. 193). The composition of this drift indicates that the ice crossed the Silurian ridge which lies to the north.

The drift of the areas near the Inn presents similar characters to the above but with the difference that local Old Red Sandstone material plays a still more important part in its composition, and gives to it a well-defined red colour, especially at the extremities of the southern branches.

A large drift-covered area commences near Pen-rhiw-gôch and the Carboniferous Limestone outlier of Bryn-yr-odyn, stretching to the west and south into the valley of the Gwendraeth-fâch towards Porth-y-rhyd. Generally speaking, it is confined to the valley-bottom, but in many cases it climbs over the lower hills.

To the immediate south of the limestone-outlier the road to Maes-y-bont crosses red till, while a section at the extreme western end of the limestone shows drift to a depth of 12 feet. To the south of the limestone and partly covering it is a stretch of red drift which is gravelly in character and evidently of local origin, although there are many far-derived striated boulders to be met with.

To the south-west of the road leading to Pen-rhiw-gôch various sections show 5 to 10 feet of red till, and from here to Garn-lwyd and down the Gwendraeth Valley to Porth-y-rhyd the drift maintains its local character.

To the east of Garn-lwyd the left bank of the river shows 30 feet of red boulder-clay and to the south of the farm the river has cut cliffs from 25 to 60 feet high in drift, composed of the same material as before.

Another mass of local drift occurs around, and to the north of, Clear Brook ; it may be described as a red gravelly till and is seen to a depth of more than 8 feet. A tongue of drift about a mile long lies south of the head waters of the Gwendraeth-fâch near, and to the west-south-west of, Maes-y-bont. The stream-banks show 20 feet of red gravelly drift made up almost entirely of local material. That the valleys of the Gwendraeth and its tributaries were wider in pre-Glacial times than at present is evident from the fact that in almost all cases one side or the other of a valley is composed of drift.

Some well-defined striations and bevelling occur on flat surfaces and crags of Millstone Grit to the west of Pentre-gwenlas, and near Garn, one mile south-east of Carmel, indicate a direction of S. 2° W. for the ice-flow. This direction is further proved by the presence of a large amount of Old Red Sandstone and Millstone Grit material in the drift of Glyn-yr-henllan on the Coal Measures to the south.

H. H. T.

At Gors-lâs and Cross Hands boulder-clay spreads widely over the upper reaches of the Gwili Valley. North-east of Gors-lâs, at Blaen-cwm-mwyn Farm, it is brown and consists chiefly of Millstone Grit débris, but with much Carboniferous limestone and some Old Red sandstone ; one large well-rounded boulder of oolitic limestone very well grooved measures 5 feet across. A similar section is exposed to a depth of 15 feet at Cwm-cerig, half-a-mile farther west ; and the Gwendraeth at the old reservoir north of Cross Hands has cut 18 feet into a like material. A still better exposure 20 feet deep is to be seen in an abandoned railway-cutting under the main road at one-third of a mile north-east of the Cross Hands Inn ; the pebbles being chiefly small pieces of Coal Measure rocks, blocks of Carboniferous grits and limestone up to 3 feet in length, some of which are well-striated, and of red and green sandstone and marls from the Old Red Sandstone. In the brook just north of The Meadows there are exposed 20 feet of stiff clay—dark and greyish-blue where unweathered—full of grit boulders derived from the Millstone Grit and Coal Measures, and ranging up to 3 feet; with many pieces of Old Red sandstone and Carboniferous limestone. Farther south the drift forms a cliff 25 feet high on the eastern bank of the Gwili 100 yards below the mouth of Meadows Brook; it is a blue clay where unweathered, full of boulders up to 1 foot, and often well-striated, of Carboniferous grits and sandstones, with pieces of coal, nodules of ironstone, very little limestone, many small pieces of Old Red marl and sandstone, and some Silurian mudstones containing fossils. The upper 8 feet of the section is finer, and contains seams of loam and coal-dust. The drift is obscurely bedded with a gentle inclination to the south-east.

West of Cross Hands boulder-clay in disconnected patches extends down the valley of the Gwendraeth-fawr; it consists chiefly of Coal Measure detritus with a proportion of Millstone Grit and Old Red sandstone. The red material is especially abundant opposite gaps in the Millstone Grit escarpment which permitted the passage of the lower débris-laden layers of ice, whereas the upper clean ice alone crossed the higher parts of the ridge. Thus, the boulder-clay covering the Carboniferous Limestone and Millstone Grit outcrops at Foel Gastell and extending westwards towards Tre-fâch and southwards over the Coal Measures towards Parc-Dai Bridge is almost exclusively of Old Red Sandstone detritus, brought from the north through the gap at Foel Gastell, and striæ on the grit 400 yards north-east of the village of Foel Gastell point S. 25° W. Farther south, however, the drift exposed in the bank of the Gwendraeth-fawr south-east of Parc-Dai Bridge consists chiefly of Carboniferous grits and sandstones with so small a proportion of Old Red sandstone that it has lost its red colour, and from this point south-westwards along the Gwendraeth and southwards up the slopes towards Tumble it contains a quite unimportant proportion of Old Red materials. Here, therefore, we appear to lose traces of the ice-flow which passed through the gap and get on the track of a flow travelling down the valley.

Still farther south, at the head of the Morlais Valley north-west of Llannon, such drift as is present contains no materials derived from any but immediately local sources. Thus for a distance of four miles south of the gap there is an absence of far-travelled material.

Under these circumstances it was a matter of surprise to find on the high Pennant scarp forming the northern flank of Mynydd Sylen, at a height of over 200 feet above this local drift, a thin gravelly deposit of exclusively Old Red Sandstone materials. It is exposed along an old lane running along the scarp west of Penllwyn-uchaf, and can be traced as far as the neighbourhood of Bryn-du. As will be seen on p. 210 the boulders on the highest parts also of Mynydd Sylen have the same character.

It is obvious, therefore, that the ice after gathering débris from the Old Red Sandstone outcrop must have carried it across the Gwendraeth-fawr Valley without picking up any Coal Measure material, presumably over-riding the ice lying in that valley.

Returning now to the Gwendraeth-fawr Valley, we find that in a lane at Ty-isaf near Tre-fâch the boulder-clay is red and consists chiefly of Old Red Sandstone grits and marls, Carboniferous grits and sandstones (chiefly Millstone Grit), Carboniferous limestone and chert, with some grits and sandstones derived from Silurian or Ordovician outcrops.

Gravelly drift derived from the Old Red Sandstone of the Gwendraeth-fâch Valley occupies the bottom of the gap in the Carboniferous Limestone escarpment at Banc-y-Mansel. It has been dug for gravel 250 yards south-east of Maes-Dulais, and consists of Old Red Sandstone pebbles with a few of Silurian or Ordovician grit. The striæ on the Millstone Grit south-west of Banc-y-Mansel show the same direction of ice-flow, and point S. 18° to 20° W. This flow probably contributed a share to the Old Red Sandstone débris on Mynydd Sylen (p. 210).

Farther south along the Gwendraeth-fawr Valley the drift is a boulder-clay chiefly of Coal Measure origin, but always contains some boulders of Millstone Grit, Carboniferous limestone, chert, and Old Red sandstone.

At Pontyberem a large gravel-mound at the back of Furnace Terrace has been cut open to a depth of 40 feet by the Gwendraeth-fawr; the gravel is brown and the pebbles are chiefly of Coal Measure grits, sandstones and shales, with some of Millstone Grit and Old Red sandstone. At the foot of the section brown loam appears.

T. C. C.

The Pennant Uplands west of the Loughor.

Of the fringe of boulder-clay, gravel and sand in the Loughor Valley near Llanedy but little can be seen. Between Cwm Daren and Gelli-gilion near Sardis gravel and sand form in places an impersistent terrace at a considerable height above the alluvium, and, near Llanedy church, a ridge running downstream obliquely towards the side of the valley. At Cwm Daren the gravel appears to have been disturbed by the landslip described on p. 155, a fact which points to the post-glacial date of the slip.

At Coed-y-cerig-fawr near the top of the slope above Glyn-Wallis, glacial striæ point due south.

Along the Gwili extensive glacial deposits have been only partly cleared out by the present stream and, as a rule, flank the alluvium on both sides. But at Plâs-newydd Mill the stream flows for a short distance through a gorge cut in the solid rock, possibly a little west of the pre-glacial channel.

In the boulder-clay which forms the bulk of the deposits hard Carboniferous rocks, such as quartzites and sandstones, predominate and Old Red fragments are rare. Gravel and sand, where they occur, generally fringe the boulder-clay and appear to pass into it. Below Pen-twyn they form terraces about 15 feet above the alluvium on either side of the river.

Between the Gwili and the Morlais boulder-clay covers two considerable areas. One, extending from Gelli-Lywarch to Llannon, is drained by two streams flowing respectively eastwards into the Gwili at Plâs-newydd Mill, and south-westwards into the Morlais at Pont Morlais. Both have cut gorges in the solid rock, in the case of the western stream apparently on one side of the pre-glacial course. In this case, also, the pre-glacial valley is slight and ill defined, most of the water having probably drained eastwards in pre-glacial times before the fall in that direction was obstructed by boulder-clay.

Few chances are afforded of observing the composition of the boulder-clay. At Lletty-newydd it consists chiefly of Carboniferous débris with occasional Old Red fragments.

The other tract of boulder-clay lies west of Tre-neddyn. It occupies the upper part of the valley which runs south-eastward past Ystlys-y-coed-isaf and is obviously of pre-glacial age. Lower down the boulder-clay has been entirely cleared and the valley deepened by a steep-sided post-glacial ravine.

The highest part of this tract of boulder-clay is drained by another stream flowing southwards past Efail-wen into the Morlais. In the upper part of its course this stream crosses what appears to have been a water-parting in pre-glacial times. It has cut through it a deep and narrow ravine, obviously of post-glacial date. By this means it joins a valley which is no less obviously pre-glacial and which leads it to the Morlais. The head-waters seem in pre-glacial times to have escaped eastwards, but to have been compelled subsequently to cross the water-parting by the piling-up of boulder-clay across their former course.

Near Ystlys-y-coed-isaf a stream-section shows that this boulder-clay consists chiefly of Carboniferous material, Old Red fragments being small and rare. There are no other good exposures.

Banc-mawr is a knoll, about 100 yards long by 50 yards wide, situated three-quarters of a mile east of Cwm Howell and rising rather steeply from the margin of the boulder-clay of which we have been speaking. It is made of Pennant sandstone resembling the surrounding country-rock but, so far as can be seen, broken and disturbed. The knoll does not fall closely into line with any neighbouring feature, but may be due to a fault which is believed to pass at no great distance (p. 139). On the other hand, as suggested by Dr. Strahan, it much resembles mounds of even larger size observed in the Rhymney and Tawe Valleys* and there known to be gigantic boulders, glacially transported.

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* W. Gibson in 'The Country around Abergavenny,' 1900, p. 94; and A. Strahan in 'The Country around Merthyr Tydfil,' 1904, p. 115, *Mems. Geol. Surv.*

Striæ at heights of about 450 and 520 feet above Ordnance Datum and near the top of the high ground separating the Gwili from the Morlais, point in the one case S. 10° E. and in the other due south.

That the Morlais Valley, though often gorge-like, is pre-glacial is shown by the occurrence in it of strips of boulder-clay down to the level of the present stream. These deposits which are well exposed to a depth of 15 feet near Pont Morlais, contain more Old Red material than those previously described, though they are still blue and consist chiefly of Carboniferous detritus. Below Pont Morlais the river has laid bare the rock-floor and revealed glacial striæ running S. 25° W., approximately in the direction of the valley.

In the drift of the lateral valleys of the Morlais, which drain the eastern part of Mynydd Sylen, the increasing proportion of Old Red Sandstone boulders is again to be observed, but on the top of the hill this change in the drift reaches its maximum. For near Bryn-du and to the east, at a height of about 800 feet above Ordnance Datum, there is a red gravelly drift composed chiefly of that rock. And the occurrence on the summit at a height of 932 feet O.D. of boulders of pebbly quartzite derived from either the Millstone Grit or Old Red Sandstone, besides showing that the highest ground hereabouts was overridden by some layers at least of the ice-sheet, proves that those layers deposited material derived wholly from ground lying beyond the neighbouring Coal Measures in the Gwendraeth valley. On the western side of Mynydd Sylen the percentage of Old Red Sandstone fragments falls again, but not so low as in the Gwili Valley.

Two facts in connection with the drift on Mynydd Sylen call for explanation, firstly the occurrence there at all of far-travelled material, and secondly its abundance on the highest ground and comparative scarcity in the valleys. With reference to the first point, the glacial striæ in the neighbourhood previously mentioned show that the flow of the ice was from the north or north-north-east, and it is clear that the ice which deposited the drift must have passed from the Old Red Sandstone lying in that direction. But the greater percentage than usual of Old Red material in the drift in the low ground immediately to the east and west of Mynydd Sylen points to a concentration of that material in a distinct part of the ice-sheet, a conclusion that is supported by what was observed in the gap at Foel Gastell (p. 207).

With regard to the second point it is evident that the ice must have passed from the Old Red Sandstone without coming into close and prolonged contact with the intervening Coal Measures. Bearing in mind that the ground on which the red drift occurs is the highest hereabouts and probably came into contact with the higher layers only of the ice-sheet, we can account for the occurrence of the red drift by the theory of overriding mentioned on p. 208.

E. E. L. D.

The lower reaches of the Morlais and Dafen Valleys are occupied by a stiff yellow or blue boulder-clay in which Old Red Sandstone blocks are scarce, and in which Coal Measure material predominates. Clearly it lies outside the influence of the flow which passed down the Loughor Valley, and though boulders of Millstone Grit and more rarely of Old Red Sandstone are dotted over the Pennant hills around Goitre, the drift of the valleys is chiefly local. Some striæ half a mile and three quarters of a mile north of Goitre range almost due south and represent the average direction of glaciation. A quarry at the eastern end of the hill of Allt shows striæ running S. 55° W., a direction partly to be attributed to the form of the ground, but there is reason to think that the ice tended to turn a little west of south in the neighbourhood, for some obscure drift-ridges between the Morlais and the Dafen have a decided westerly element in their direction.

The drift which covers much of the upper part of the Lliedi Valley is generally a stiff blue clay, with a few small blocks of Old Red Sandstone, but sometimes dotted over with many large boulders of quartz-grit and quartz-conglomerate. In the west side of the upper reservoir blue laminated clay and sand, without stones, crop out a little above the level of the brook, as though interbedded in the boulder-clay, and on the opposite side of the brook, between it and Cwm Llethriad, sand and gravel forms a moundy platform at a height of about 100 feet above the streams. A curious little promontory of sand occurs again 450 yards N.W. of Gelli-lysged, with boulder-clay against its foot.

At the head of Cwm Llethriad there are three ridges of boulder-clay with two well-marked hollows between, on the east side of the brook. Their origin is not obvious, but they resemble the ridges in which the drift was often deposited, at least as much as erosion-features.

A. S.

CHAPTER XIII.

SUPERFICIAL GEOLOGY (*continued*).

POST-GLACIAL DEPOSITS.

River-Terraces and Deltas.

Terrace-like accumulations of gravel and sand occur in the neighbourhood of Llanarthney on the south side of the Towy Valley, on the eastern flank of its tributary the Dulais Valley, and at the mouth of the large open valley which holds the Nant-Celyn. At Llanarthney these gravels occupy an area of about half a square mile traversed by the little river Gwynon which flows down from Middleton Hall.

The gravels at their eastern end slope gradually down to the level of the Towy alluvium, but to the west show an abrupt fall of several feet. The Gwynon has cut into them south of Llanarthney and shows 6 to 12 feet of fine gravel with little or no Old Red detritus, most of the material being fragments of older rocks. To the west of Llanarthney sections may be seen along the railway at Bremenda, where the gravels rise 20 feet above the alluvium of the Towy, in a low cliff above the Towy to the north-east of Bremenda-isaf, and at Pont-ar-ffinnant. The gravels of the last exposure were searched in vain for Old Red Sandstone material. The deposits at Felindre, which have been largely cut into by the Dulais and the Towy, and those at Pont-Celyn, are at a slightly lower level, but have probably had an identical origin.

The gravel-areas of Llanarthney and Bremenda include a mass which is identical in composition, but rises to a height of about 40 feet above the terrace. The moundy outline of the mass points to its being of glacial origin as described on p. 194, while the character and form of the terrace points equally to its being a fluviatile formation, but it proved to be extremely difficult to separate the mounds from the terrace. It seems probable that the terrace was formed in early post-glacial times by the partial redistribution or planing-down of the moundy gravel.

H. H. T.

A terrace or delta of gravel and sand overlooks the alluvium of the Amman and the Garnant at their confluence; it consists chiefly of coarse boulder-gravel with little matrix; but an old drift in search of coal on the south side of the Amman Valley is said to have got into quicksand. Similar terraces border both sides of the Pedol, and small deltas lie opposite the mouths of the Berach, Garenig, and Creigle.

Much more extensive gravel-spreads are developed at Ammanford at the junction of the Amman and the Loughor rivers. On the south side of the Amman a terrace forms a high bank bordering the alluvium at the chemical works; and at Pen-tŵyn, 400 yards below Pontamman, it is being undercut by the river into a vertical cliff, 30 feet high, of coarse subangular gravel with a clean brown sandy matrix, the boulders being of Coal Measure, Millstone Grit, and to some extent of Old Red Sandstone origin. Lower down stream it forms the site of the village of Bettws, and south of Nant-y-ffîn it takes the form of long narrow ridges nearly parallel to the river. Beyond this point it can be traced as far as the mouth of Cwm Cathan.

Between the Amman and the Loughor the same class of gravel can be traced from Pontamman through Ammanford to the confluence of the Loughor and Marlais; at Tirydail the gravel projects onto the alluvium and forms the site of an ancient entrenched mound.

The same gravel forms a small terrace between the Marlais and the Lash at Aberlash, and farther south there are traces of the terrace on the west side of the valley at Pant-y-ffynnon, while at Parc-y-Rhyn opposite Bettws there is a large patch of the terrace surrounded on all sides by alluvium, isolated apparently by the action of either the Loughor or the Amman.

At Talhardd in the Cennen Valley, three-quarters of a mile south-west of Ffairfâch, a thin terrace bordering the alluvium contrasts strongly with the surrounding glacial drift (p. 192), in being composed wholly of Old Red Sandstone material.

T. C. C.

At the mouth of almost every dingle opening into one of the deeper valleys, such as those of the Dulais, Tawe, or Loughor, there are deltas of loose boulder-gravel, washed down from the steep hill-sides and shot on to the alluvial flat. Though small they show the conical shape which characterises such deposits in mountainous regions. They are still being added to in floods, though not so rapidly as in early post-glacial times. Part of Pantardawe is built on the delta of the Upper Clydach.

A. S.

Alluvium.

The alluvium of the River Towy occupies a tract, averaging two-thirds of a mile in width from Golden Grove to Llanarthney, but to the north of Golden Grove reaching as much as one mile, while at Llanarthney and Llanegwad it narrows to one-third of a mile. At Cilsân Bridge (Golden Grove) its average height above sea-level is from 65 to 75 feet, but at Llanarthney the level is from 40 to 50 feet, showing a fall of 20 to 25 feet in five miles.

In composition it is largely made up of pebbles of Silurian and Ordovician rocks, but at the same time it contains so much Old Red Sandstone material as often to give it a red colour. This Old Red Sandstone material has probably been introduced into the Towy Valley by two tributary streams, the Sawdde and the Cennen. Where the Sawdde, after traversing a narrow rocky gorge which drains Old Red Sandstone country, enters the wide Towy Valley at Llangadock (Sheet 212), it has formed a deltaic mass of shingle largely composed of Old Red Sandstone material which is always being redistributed by the waters of the Towy. The same is true but in a less degree in the case of the more slowly flowing Cennen, which enters the Towy Valley at Ffairfâch near Llandilo (Sheet 212).

A large part of the Towy alluvium is liable to floods which have formed flood-channels, breaking the level of the alluvial flat, and forming in some cases a natural floodbank, which makes itself evident as a rise of a few feet.

Several good overflow channels may be seen between Ro-fawr Farm and Dryslwyn, and these, when filled with water, are known as moats. A little to the west of Pentre-Davies Farm the river made a very pronounced loop, but ultimately cut through the narrow neck which separated the two sides of the bend, and thus formed an 'ox-bow' lake.

Occasionally a slightly higher alluvium rises, in a terrace-like form, a few feet above the general level; such a rise may be traced across the road south of Golden Grove Station for about half-a-mile to the west. In the valley of the River Dulais the western side is flanked by a slightly higher alluvium running up from Ty-pica to the west of Felindre about 350 yards from the river. Also near Llanegwad to the south of Cincoed a narrow strip runs westward from Llwch-gwyn.

Some remarks on the alluvium of the Tawe will be found on p. 201, and on that of the Loughor on pp. 204, 205.

H. H. T.

Peat.

Peat occurs on the outcrops of the more impervious rocks—the Lower Limestone Shales, the middle subdivision of the Millstone Grit, the Coal Measures, and the boulder-clay—though it is not made use of anywhere within the area embraced by the map. Peat-bogs which occupy definite hollows are shown on the map, but much of the Millstone Grit moorland is covered by hill-peat to which it is impossible to draw a definite margin.

T. C. C.

A few patches of peat are found at Llanedy and at the head of the Lliedi Valley, but their greatest development is eastward and south-eastward of Llannon, where they are due in part at least to the abundant water thrown out along faults. They generally occur on boulder-clay, spreading with ill-defined boundaries over its surface, and not, as a rule, occupying hollows. Most of them are covered with living vegetation, but some are wasting into black peat-hags. None appear to have been used as sources of fuel. The peat which is being formed at the present time is made of grass, rushes, heather, bog-myrtle, etc, with little moss.

E. E. L. D.

CHAPTER XIV.

ECONOMIC PRODUCTS.

(EXCLUSIVE OF COAL.)

Ironstone.

The shales between the seams of coal in the lower series contain numerous bands of ironstone (locally 'mine') in the form of 'balls' and 'pins.' The ironstone is an impure ferrous carbonate and contains 25 to 35 per cent. of the metal. When associated with much carbonaceous matter it is known as blackband ore.

The clay-ironstones were largely worked in the early part of the nineteenth century at Ystalyfera in the Tawe Valley, at Brynamman in the Amman Valley, and at Pontyberem in the Gwendraeth-fawr Valley, at all of which places there were extensive blast-furnaces, now long extinct.

The ore was obtained from the shales associated with the lower group of coal-seams, and was got both by levels and by opening 'patches' or quarries in the shales. Where a stream was available this was sometimes turned onto the crop of the mine-ground or dammed up and allowed to rush over the crop, so as to wash away the shale from the ore. The process was known as 'scouring.' The patches at Ystalyfera extend along the south side of Cwm Twrch. The mine occurred at several horizons, but one of the most noted was associated with the Little Vein. Those at Brynamman lie along the south side of the Amman Valley for about a mile and three-quarters, and the ore was smelted at adjacent furnaces; a large pile of slag may be seen south of the Great Western Railway Station. There are numerous patches in Cwm Garnant and they extend westwards across Nant-y-gath; there are others north of Gelli-caedrum.

On the Loughor, between Dre-fâch and Glyn-hîr, ironstone as well as coal (p. 114) is said to have been got and smelted about a century ago at Forge Llandyfan, where edged tools appear to have been made, but it is doubtful if the ore was smelted there.

At Gors-lâs, three miles west-south-west of Llandybie, the ironstone associated with the Lower Pumpquart and Lower Triquart coals was opened up about the year 1804, and a tramline constructed thence to the blast-furnaces at Llanelly, but the enterprise seems soon to have been abandoned. The present Llanelly and Mynydd Mawr Railway follows the old tramline.

At Pontyberem blast-furnaces were in operation some years ago, the ore chiefly smelted being the Rhâs-fâch mine from the neighbourhood of Pont Henry on the adjacent map (229) to the west.

A blackband, 1 foot 8 inches thick, was much worked under Farteg Hill and Rhôs Common; it lies between the Red and Four-feet Veins. A band below the Red Vein (p. 104) has been tried also at Gelli-warog, south of Cwm Twrch; and others, above the Red Vein at Gelli-fawr on the western side of Cwm-y-gors, south of Brynamman (p. 110) and near the old Cawdor Colliery (p. 111).

The decay of the clay-ironstone industry is attributed to the importation of foreign ore. There is no lack of the raw material.

Lime and Limestone.

Lime has been burnt all along the outcrop of the Carboniferous Limestone wherever its surface is free from drift or Millstone Grit débris. Some of the old quarries on the Black Mountain are remote from habitations and the lime was conveyed by pack-horses or mules along bridle-roads now scarcely traceable, as, for instance, from the old quarries in the Twrch Valley at the mouth of the Twrch-fechan. Much lime was burnt at Careg-yr-ogof (1,924 feet) south of Llanddeusant (Sheet 212). Farther south, dark limestone was quarried by the Black Mountain Company immediately north of the peat-bog at the head of Nant Llynfell. The rock belongs to the lowest part of the Main Limestone (p. 67). The following analyses were communicated by Mr. John Hay:—

Black Mountain Limestone.

Lime (CaO)	55·0	98·0
Carbonic Acid (CO_2)	42·9	
Alumina and Fe_2O_3	·5	·65
Magnesia	·55	·82
Silica	·4	·72
Phosphorus	·02	
	99·37	100·19

The most extensive quarries are at Pen-rhiw-wen, north of Brynamman, where the escarpment is covered with old kilns. Lime was burnt here as late as 1899 at the 'Craig-y-nôs and Blaen-y-gwawr Kilns,' and some years previously, when the use of lime was general among the farmers, a vast quantity was carted to places as far off as the borders of Cardiganshire. About 1899, when the price of coal rose, the industry ceased.

At the Cincoed Limeworks and at the Garn-fâch quarries at Llandyfan lime was no longer being burnt in 1901, and the Pistyll Limeworks north of Llandybie ceased work about the same year, but the industry was active at Cil-yr-ychen Limeworks which are situated on the railway. There the rock is burnt for lime and also crushed for road-stone. At Pentre-gwenlas, a little farther west, quarries were being opened up in 1901 by a new company, and a branch line has been constructed thence to the Mountain Branch of the Great Western Railway near Ammanford.

T. C. C.

To the west lime-burning seems to be an industry still on the decline, and lime is seldom used for agricultural purposes. An immense number of disused kilns may be seen on the limestone-outcrop, and the quarries are too numerous to mention in detail; they are most frequent in the district between Pentre-gwenlas and Allt-y-garn, and in the neighbourhood of Castell-y-gareg. Limestone is also quarried in the faulted mass at Trawsdre-isaf, and at one time was burnt there. There are several more or less disused limestone quarries at Bryn-yr-odyn, and also the remains of a kiln a few yards to the south of the farm; this undoubtedly gave rise to the name Bryn-yr-odyn (Hill of the kiln). The limestones of Llandilo age have been extensively quarried, but the rock is unsuited for conversion into time, and is never burnt. The Bala Limestones are generally impure; they were quarried for local purposes, and were burnt at Crûg, Birdshill, and Allt Cincoed.

H. H. T.

At the Pen-y-garn quarries south of Wîg no kilns were working in 1902, nor were there any as far west as the edge of the map north of Pontyberem.

Rottenstone.

An account of the more easterly of the rottenstone-workings and the chemical composition of the products has been given in a former part of this memoir.*

In the area embraced in the Ammanford Sheet rottenstone has been dug at one time or another all along the outcrop of the highest beds of the Carboniferous Limestone (wherever their outcrop is sufficiently clear) as far as Llandyfan. Also it has been worked at the small inlier of limestone shown on the map at the south-west end of Tair Carn.

The more recent operations have been carried on along the eastern side of Pen-yr-alleg in the Twrch Valley, at Carn Pen-y-Clogau and Carn Cennen north of Brynamman, and at Garn-bica near Llandyfan, at which places a little appeared in 1900 to be raised occasionally.

West of Llandybie occasional old trials may be seen, as at Pentre-gwenlas. West of Foel Gastell there are no trials.

Silica Sand.

Loose sand formed by the disintegration of the Millstone Grit has been extensively dug for use in steel-furnaces to protect the fire-bricks, and the grit itself where sufficiently soft to be quarried has been wrought for the manufacture of fire-bricks.*

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* 'The Country around Merthyr Tydfil,' 1904, pp. 121–124, *Mem. Geol. Surv.*

In 1899 a company was quarrying soft grit near Pen-yr-alleg on the Black Mountain north of Cwm Twrch and conveying the material by an incline to works in Cwm Twrch. The rock quarried close to the winding-engine is a soft yellowish-white pebbleless grit. A disused quarry by the side of the incline one-third of a mile south of the winding-engine shows 12 feet of grit over black shale exposed for 7 feet. A level in the shale was opened for obtaining a supply of it for use as fireclay. Farther north there are extensive old workings near the peat-bog at the head of Nant Llynfell in disintegrated grit, but the operations had ceased by 1899. Boulders of Millstone Grit were being picked out of the bed of the Twrch and ground up for the manufacture of fire-bricks in 1899.

The following analyses of some of the Black Mountain materials were communicated by Mr. John Hay:—

Analyses of Silica Sand and Sandstone.

	1	2	3	4	5	6	7	8	9	10	11
Silica -	95·84	99·15	93·1	94·6	96·6	95·8	97·7	98·1	98·2	97·9	98·2
Alumina -	2·85	·88	3·2	2·1	1·8	2·2	1·4	1·0	·8	1·0	·9
Iron oxide	trace	trace	2·8	2·6	1·0	1·4	·7	·7	·5	·6	·5
Lime -	trace	—	·65	·24	trace	trace	trace	trace	—	trace	trace
Magnesia -	·12	—	—	—	—	—	—	—	—	—	—
Potash -	·13	—	—	—	—	—	—	—	—	—	—
Soda -	·24	—	—	—	—	—	—	—	—	—	—
Loss - -	·34	0·13	—	—	—	—	—	—	—	—	—
	99·52	100·16	99·75	99·54	99·4	99·4	99·8	99·8	99·5	99·5	99·6

1. Black Mountain Sand. 'Very refractory . . . very good quality for use in Siemens furnaces.'

2. Black Mountain Sand. Analysis by E. W. Harvey. Dried at 100° C.

3 to 9. Black Mountain Silica Sandstone. Analyses by T. R. Williams. Heat tests for two hours in Siemens furnaces: No. 3 slightly fusible; No. 4 very slightly fusible; Nos. 5 to 9 infusible.

10 and 11. Black Mountain Silica Sandstone from west side of incline. Analyses by T. R. Williams.

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* For an account by Dr. A. Strahan of the manufacture of fire-bricks from a similar material at Dinas reference should be made to 'The Country around Merthyr Tydfil,' 1904, p. 124, *Mem. Geol. Surv.*

Analyses of Silica Brick.

	1	2	3	4	5	6
Silica - -	96·10	95·40	96·30	95·95	96·4	95·80
Alumina - -	1·85	1·70	1·60	1·90	1·8	·74
Oxide of iron -	·57	·74	·80	·70		·95
Lime - -	1·15	1·60	·98	1·00	1·9	2·15
Magnesia - -	trace	—	—	—	—	—
	99·67	99·44	99·68	99·55	100·1	99·64

1 to 4. Silica brick, unburnt.
5. Silica brick from Black Mountain Stone. Analysis by T. R. Williams.
6. Silica brick from crushed stone at top of incline. Analysis by T. R. Williams.

Disintegrated Millstone Grit, or silica-sand, was being carted by road in 1900 from Pen-rhiw-wen to Brynamman Station. In one of the disused pits the material consists of grit-débris, and rotten grit with seams of brown, yellow, and black shale with a thin coal-smut. In a pit which was working in 1900, a little farther south, traces of the original bedding show dips of 50° or 60°. On the east side of the pit was exposed a lenticular mass of coal 3 feet thick (p. 83).

On the north side of Tair-Carn-uchaf the soft grit near the south-western end of the peat-bog at the head of Gwythwch Brook has been dug by the farmers for sharpening scythes.

North of Forge Llandyfan soft grit was formerly dug at some quarries south of Llwyn-Dewi Farm. Farther west, at Llandyfan, the Bynea Brick Company were quarrying the Millstone Grit in 1901 at Garn-bica, and more recently a new quarry has been opened south of the Pistyll Limeworks at Llandybie. There are several old sand-pits on the west side of the Llandybie Valley at Pentre-gwenlas. Near Llyn-Llêch-Owen north of Gors-lâs the Millstone Grit is friable and has been quarried for silica-sand; there are old pits on Foel Gastell also. At Banc-y-Mansel a large sand-pit was opened in soft grit to a depth of 30 or 40 feet, and the grit was crushed at a mill hard by. The pit was closed about the year 1899.

Plastic Clay.

In a level at Garn-bica near Llandyfan the Bynea Brick Company has been working 'plastic clay.' As already explained on p. 75 certain fine-grained siliceous sediments at the base of the Millstone Grit have disintegrated and the residue forms a deposit of nearly pure silica as fine as flour. This material, of which there is a very limited supply, is worked under the name of 'plastic clay' as a cement for the lining of steel-furnaces.

It does not appear to have been discovered east of Llandyfan, but it seems to persist for some distance westwards, evidence having been obtained of its occurrence in a small pond at the foot of the Millstone Grit escarpment south of the Pistyll Limeworks at Llandybie.

T. C. C.

Plastic-clay has been worked at various points along the outcrop from near Pentre-gwenlas on the east to Allt-y-garn on the west. A level was driven in on the outcrop on the main road to the south of Glan-Gwenlas Farm, and a slant was driven along the strike opposite Garn Farm. To the west of this point there are no old workings.

It is probable that some rottenstones also were taken from these levels, etc., but there is no record.

H. H. T.

At Banc-y-Mansel there are evidences of the presence of the plastic-clay beds and rottenstone beds at the top of the Carboniferous Limestone south of Maes-Dulais, and again half-a-mile farther west in a disused millrace at Ty'r-felin, and also at Garn on the western edge of the map, but at none of these places do trials appear to have been made.

Fireclay.

The following analysis of fireclay, made by Mr. T. R. Williams and communicated by Mr. John Hay, probably refers to a bed of shale under one of the grit-beds on the east side of the incline on the Black Mountain (p. 83).

Black Fireclay from the Millstone Grit.

Hygroscopic water 7·556 %. Sample dried at 100° C.

Silica	60·9
Oxide of iron	trace
Alumina	29·0
Lime	nil
Combined water	10.2
Volatile matter etc.	—
	100·1

Building Stones.

The Ffairfâch Grit at the base of the Llandilo Flags, the limestones in the Llandilo Flags, the Lletty Grit in the Ludlow Beds, and the Trichrûg Beds at the top of the Silurian have all been quarried for local building-purposes.

Some sandstones in the Red Marls or lower subdivision of the Old Red Sandstone have been used for local building-material, but the overlying Senni Beds have yielded flaggy green and red micaceous sandstones of better quality. The latter have been quarried at Llyn-y-beddau near Trapp, and elsewhere.

The new church opened at Gwynfe in 1899 was built of a hard red sandstone obtained from the Brownstones of the Old Red Sandstone at the seventh milestone from Llangadock on the Brynamman Road.

Llandyfan Church was re-built with a red sandstone in the Brownstones from a quarry 150 yards south of Blaen-gweche.

At Cil-yr-ychen the highest beds of the Brownstones are quarried (p. 63); the rocks are red and brown sandstones, some coarse-grained, others fine and micaceous.

The pebbly olive-green and red coarse sandstones at the top of the Brownstones have been quarried between Llandyfan and Llandybie, and again at Pentre-gwenlas.

The Carboniferous Limestone is used largely, in the district where it crops out, for building and walling.

Sandstone-bands in the Millstone Grit Shales, notably between Cross Hands and Pontyberem, the Farewell Rock, as at Craig-derlwyn north of Brynamman and at Pontyberem, and sandstones in the lower part of the Coal Measures have been occasionally quarried for local use. The chief lower Coal Measure rocks are the Bryn Vein rock, quarried in Nant-melyn, Brynamman; the Big Vein rock, quarried at several places in the Amman Valley; the Stanllyd rock, and the Rock Vein rock in the Llandybie district.

In the upper part of the Lower Coal Series the sandstones which correspond in position to the Llynfi Rock elsewhere and in most respects resemble the Pennant Sandstones have been quarried extensively. South of Cwm Llynfell one of these sandstones was worked at the Bryn-melyn Quarry and the material carried by an incline to the Gwaun-cae-gurwen Railway.

South of Glanamman a sandstone below the Red Vein at Twll-gwyn is stated in the Logan MS. (1836–42) to be 14 yards below the coal and to have been extensively worked for flags.

Near Bettws a quarry was opened in a good band of Pennant-like sandstone in Nant-y-ffîn north-east of Maes-y-cwarau. An outlier of fine flaggy Pennant-like sandstone a mile south of Cross Hands, and the outcrops of the sandstones below the base of the Pennant south of the Gwendraeth-fawr Valley have all been quarried for local building purposes.

The Pennant Sandstones have been quarried over the whole outcrop, but none of the quarries are used for other than local purposes. The largest quarries are at Bolgoed near Pontardulais, and near the lower reservoir in the Lliedi Valley.

T. C. C.

Small quarries exist at several places along the outcrop of the Ffairfâch Grit, and were probably opened for building-purposes;

one is situated a little to the north of Golden Grove House and another at the western end of Carbury Mount. The Golden Grove quarry yields a stone which is more durable than the other as it contains less carbonate of lime and is less affected by atmospheric conditions.

The Llandilo flags and limestones were in the past extensively worked, the former for paving and the latter for building. The quarrying of flagstones in this district, however, is now almost a thing of the past as the demand for them seems to be on the decrease. The thicker limestones have been quarried at the Keeper's Lodge and to the north of Pant-glas near Carbury Mount for building-stone. These limestones, owing to their flaggy character, are difficult to dress, and their tendency to pass into ochreous rottenstones renders them more or less unfit for unfaced buildings, so structures of this material are usually faced with Carboniferous Limestone or stucco.

In the Old Red Sandstones, the green and pale-coloured sandstones are those chiefly worked for building-purposes. These rocks usually form part of the Green Basal Beds, the Senni Beds, or of the pebbly series of sandstones underlying the Carboniferous Limestone. The red sandstones in the Red Marls and Brownstones are quarried, but less frequently.

Some sandstones in the red marls of the lower subdivision of the Old Red Sandstone have been used for local building materials. Several disused quarries exist near Middleton Hall, one at Holywell Farm and another near Clear Brook.

The Senni Beds have yielded greyish-green sandstones to the north of Carmel and to the west of Garn-llŵyd, but have not been in much request.

The Brownstones contain several hard sandstones which have been worked to a small extent as at Wîg.

The harder pebbly sandstones have been quarried along the road east of Carmel and at Capel-Llan-Lluan.

H. H. T.

Tilestones.

Formerly the highly micaceous and fissile sandstones at the top of the Ludlow rocks (p. 51) were worked on a large scale for tilestones; these may still be seen on old buildings in the neighbourhood, but their use has now been wholly relinquished in favour of slates. The beds are vertical and were worked along their outcrop in narrow quarries ranging up to 800 yards in length as at Cilmaenllwyd, north-east of Trapp. There two bands suitable for tilestones were worked. The rock was split into slabs about half an inch thick and then dressed into tilestones. The tile was then pierced for a wooden peg, by which it was hung on the timbers of the roof. The workings extend westwards as far as Golden Grove.

T. C. C.

Tiles seem to have been taken from an old quarry just within the wall of Golden Grove Park to the north of Caeth-argoed; and in the lower green series of the Old Red Sandstone fissile green beds have been quarried for tiles near Golwg-y-byd and Cefn-Berach Chapel, and at intervals along the outcrop to Nelson's Tower.

H. H. T.

Roadstone.

The principal sources of roadstone are the limestones in the Llandilo Flags, sandstones in the Old Red Sandstone, all varieties of the Carboniferous Limestone, sandstones in the Millstone Grit, and 'cockshot rock' bands in the Coal Measures. Much Carboniferous Limestone is taken by rail from the quarries at Llandybie and Pentre-gwenlas. The main roads are generally repaired with Carboniferous Limestone.

T. C. C.

In the Llanedy and Llannon district boulders collected in the ploughed fields are used locally, but the more quartzitic varieties of Pennant, like that quarried to the south of Gwal-yr-hwch (E. 3592, p. 155), and at Fforest (p. 166), form a more suitable source of material.

E. E. L. D.

Water Supply.

The water-supply is obtained from shallow wells, springs, and the impounding of surface-waters.

The village of Cwm Llynfell is supplied with highly-ferruginous water which bursts out from shales above the Red Vein at Pant-y-bara, a little west of the Cwm Llynfell Fault, and the adjoining village of Ystrad-Owen utilises a spring near the same line of fault.

The water-supply of Upper Brynamman is derived from a spring on the south-west slopes of Gareg-lwyd, on the line of the Cwm Llynfell Fault, which throws the impervious shales of the Millstone Grit against the porous basal grits.

Llygad Llwchwr, where the Llwchwr issues from a cavern in the Carboniferous Limestone, has been under consideration as a source of supply for one of the large towns beyond the limits of the map, but the water becomes turbid after heavy rains. The Logan MS. records that the flow had been ascertained to be 63 tons per minute, which is equal to 14,112 gallons per minute.

A powerful issue from the Carboniferous Limestone at Llandyfan is used to supplement the water-supply of Llandilo, which was previously derived from the impounding of small streams on the south side of the Cîb Valley.

The Glanamman district depends on several springs from the Farewell Rock on the north side of the Amman Valley. Cross Hands utilises a spring on the west side of the Bryn-gwili Fault near Pant-gwyn, and Tumble makes use of a spring on the line of the Tumble Fault. Pontyberem depends on an impounded stream.

Smaller villages and hamlets resort to some local spring (*e.g.*, St. Tybie's Well at Llandybie) or to a village pump, as at Bettws.

Some of the springs from the Carboniferous Limestone (p. 68), although sufficiently copious, are not yet utilised for any public supply, as, for instance, Ffrwd-ar-Dwrch, part of the waters of which are derived from swallow-holes near the peat-bog at the head of Nant Llynfell.

T. C. C.

A few springs mark the junction of shales with overlying sandstones; others, but more frequently indefinite 'soaks', are found along the upper margin of sheets of boulder-clay. But the most powerful as well, apparently, as the freest from ferruginous contamination, occur along faults, of which the most noteworthy in this respect is the Llannon Fault. Its course near Llannon is marked by an almost continuous line of springs of which St. Non's Well, near Pen-y-cwm-fawr, supplies the village-fountain. To the south-west of Mynydd Sylen, also, much water is thrown out, the spring at Gelli-hir, just outside the map, being very powerful. The Pont Morlais Fault is another along which much water issues, and at Tre-neddyn what is supposed to be a branch of this throws out a particularly large volume (p. 162).

E. E. L. D.

Villages on the Towy receive their water from wells sunk in the alluvium or river-terrace gravels. The majority of farms are supplied from shallow wells sunk on a line of springs between two deposits, usually boulder-clay and solid rock, or on fault-lines as at Pant-glas (p. 18).

H. H. T.

Mineral Springs.

Many of the springs on the Coal Measures are ferruginous, and calcareous springs are frequent along the base of the Carboniferous Limestone.

In 1840 a sulphur spring was discovered on sinking wells for the supply of the Griffin Inn, on the Neath Road 5½ miles from Llangadock and just north of the margin of the map. From information communicated by Major C. Bassett Lewis it appears that wells were sunk on both sides of the road, but that the taste and smell of the water led to its being analysed, with the result that it proved to be strongly impregnated with sulphuretted hydrogen and salts of iron. A pumphouse having been erected opposite the Griffin Inn, and the New Inn and several cottages built, the place became known as Clydach Wells, but by the year 1865 it had fallen into disuse. The water now has neither taste nor smell.

The surface of the ground is occupied by boulder-clay made up chiefly of Old Red Sandstone materials ; the underlying rocks are Old Red marls. Neither deposit is known to yield such water elsewhere, and the source of the temporary peculiarities of the water remains problematical.

T. C. C.

APPENDIX.

Lower Palæozoic Fossils from Sheet 230 in the Museum of Practical Geology.

Tremadoc.

Ogygia marginata,* *C. and S.*, p. 7.
Olenus (*sensu lato*), p. 14.
Peltura punctata, *C. and S.*, pp. 6, 7.
Orthoceras perannulatum ? *Portl.*, p. 7.

Arenig.

Ogygia marginata Beds.

Ogygia marginata,* *C. and S.*, pp. 14, 15.
Orthoceras sp., p. 14.
Hyolithus sp. [Theca, *Auctt.*], p. 14.
Redonia anglica, *Salt.* sp., p. 15.
Lingula sp., p. 14.
Obolella sp., p. 14.

Didymograptus bifidus Beds.

Ampyx salteri ? *Hicks*, p. 16.
Ampyx sp., p. 16.
Asaphus tyrannus, *Murch.*, p. 16.
Barrandia sp., p. 16.
Calymene hopkinsoni ? *Hicks*, p. 16.
Ogygia *cf.* corndensis, *Murch.* sp., p. 16.
Ogygia selwyni ? *Salt.*, p. 16.
Phacops llanvirnensis, *Hicks*, p. 16.
Trinucleus *cf.* ramsayi, *Hicks*, p. 16.
Trinucleus n. sp., p. 16.
Hyolithus sp. [Theca, *Auctt.*], p. 16.
Palæarca ?, p. 16.
Lingula hawkei, *Rouault*, p. 16.
Lingula sp., p. 16.
Monobolina plumbea, *Salt.* sp., p. 16.
Siphonotreta micula, *M'Coy*, p. 16.
Climacograptus *cf.* confertus, *Lapw.*, p. 16.
Climacograptus sp., p. 16.
Didymograptus acutidens, *E. and W.*, p. 16.
Didymograptus artus, *E. and W.*, p 16.
Didymograptus bifidus, *Hall* sp., pp. 17, 18.
Didymograptus murchisoni, *Beck* sp., p. 16.
Didymograptus murchisoni, *Beck* sp., *var.* geminus, *His.*, pp. 16, 17.
Didymograptus patulus ? *Hall* sp., p. 16.
Didymograptus stabilis, *E. and W.*, p. 16.
Nemagraptus ?, p. 16.

Llandilo.

Asaphus peltastes, *Salt.*, pp. 25, 28.
Asaphus powisi, *Murch.*, p. 19.
Asaphus tyrannus, *Murch.*, pp. 23, 25, 26, 27.
Calymene blumenbachi, *Brongn.*, p. 25.
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